Cosmic evolution and large-scale structure

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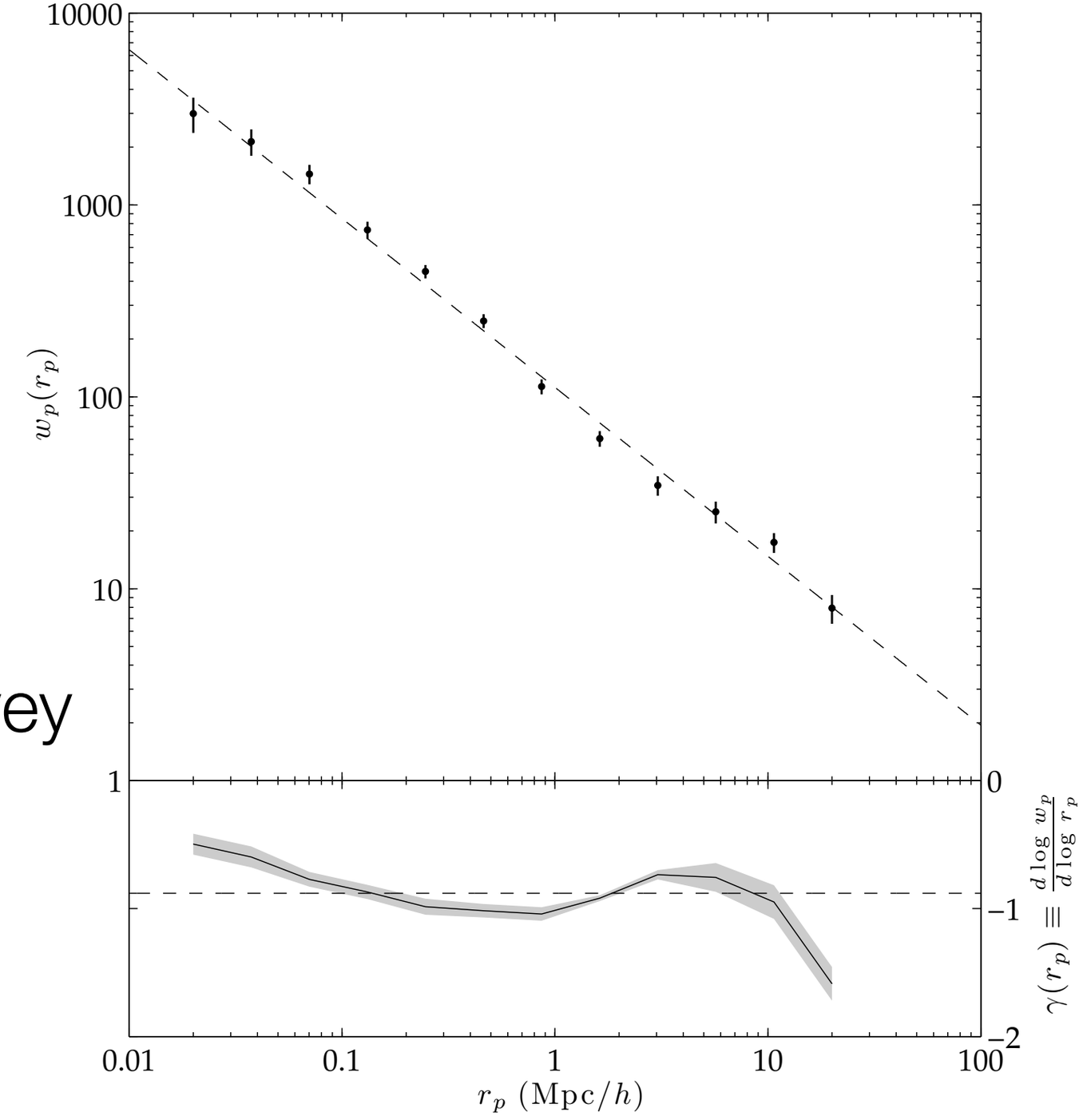
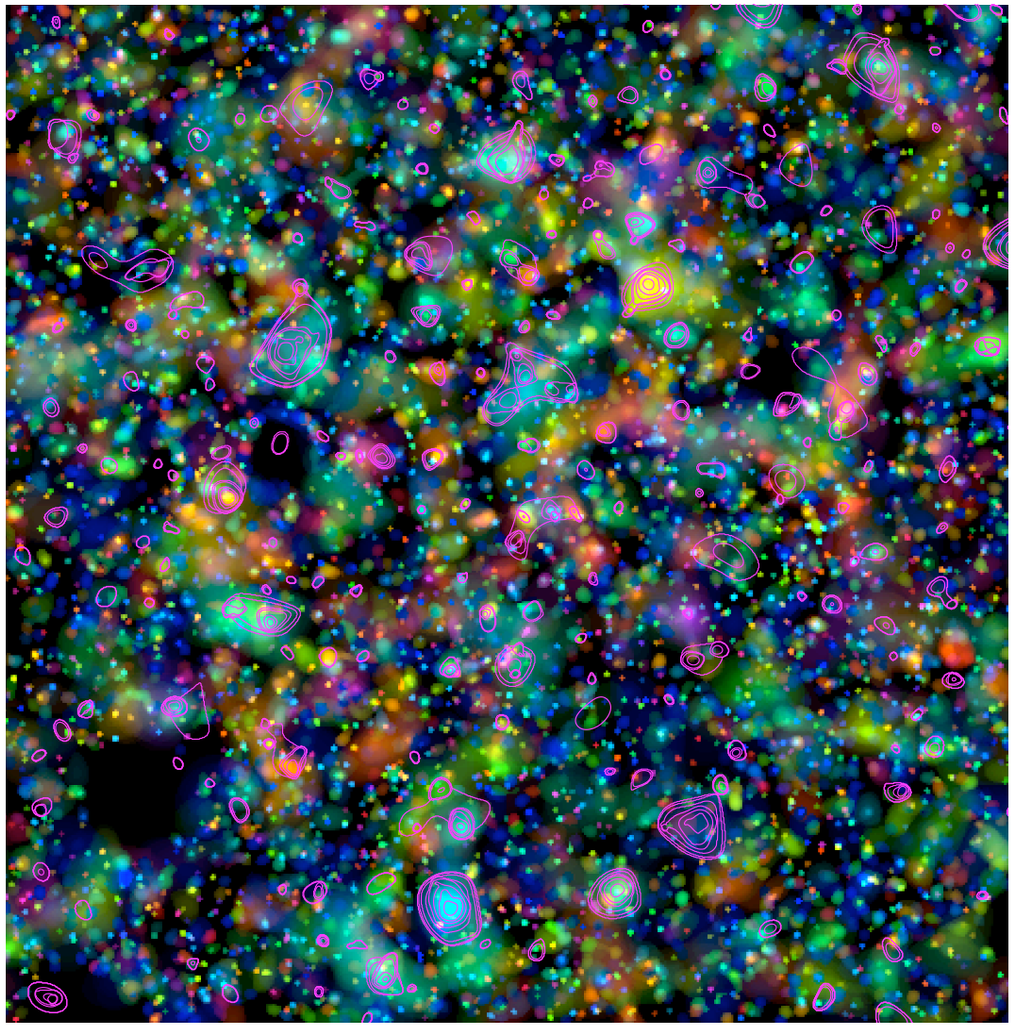
Copenhagen / Berkeley

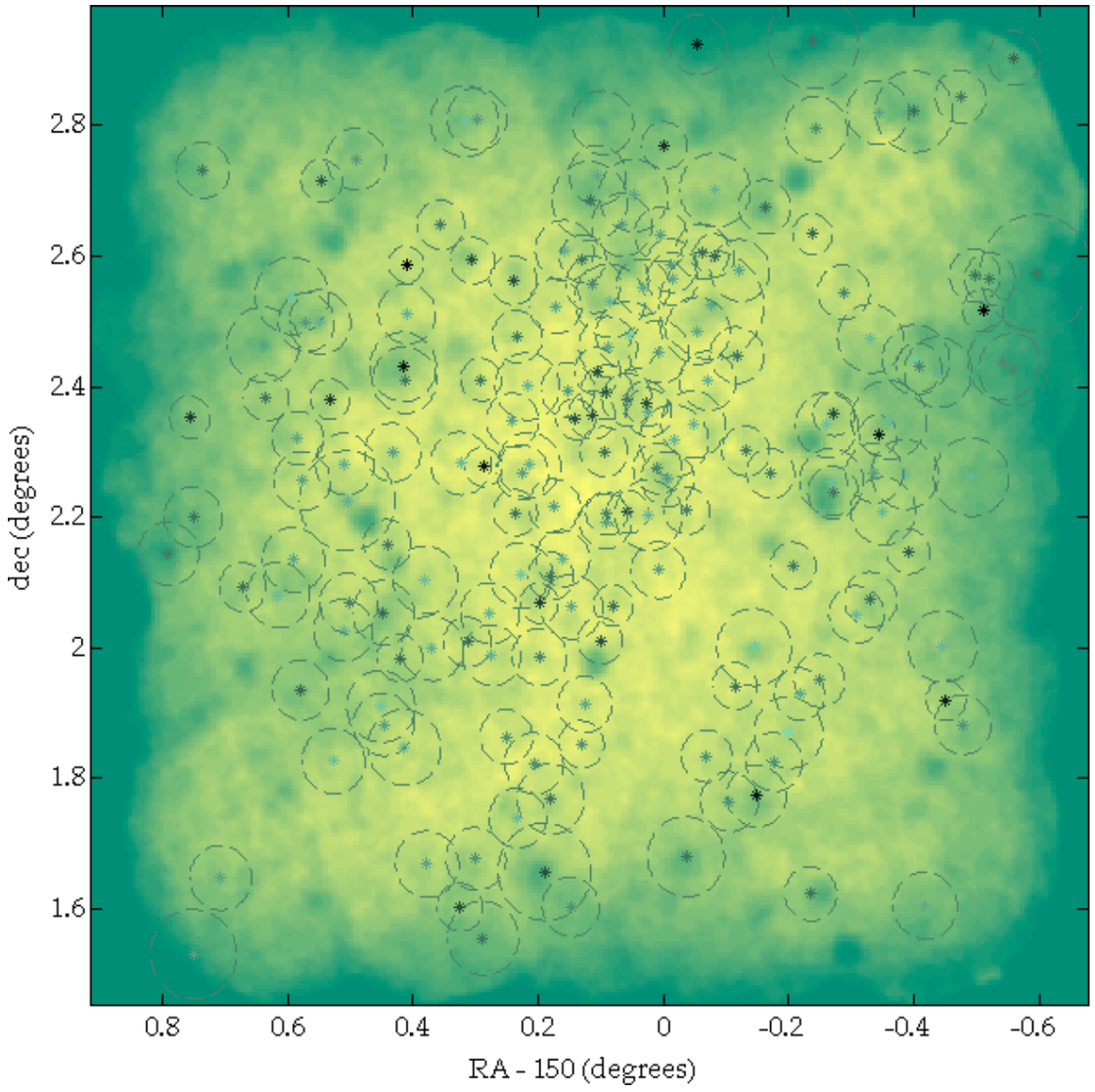
One

Clusters and galaxies in the Cosmic Evolution Survey

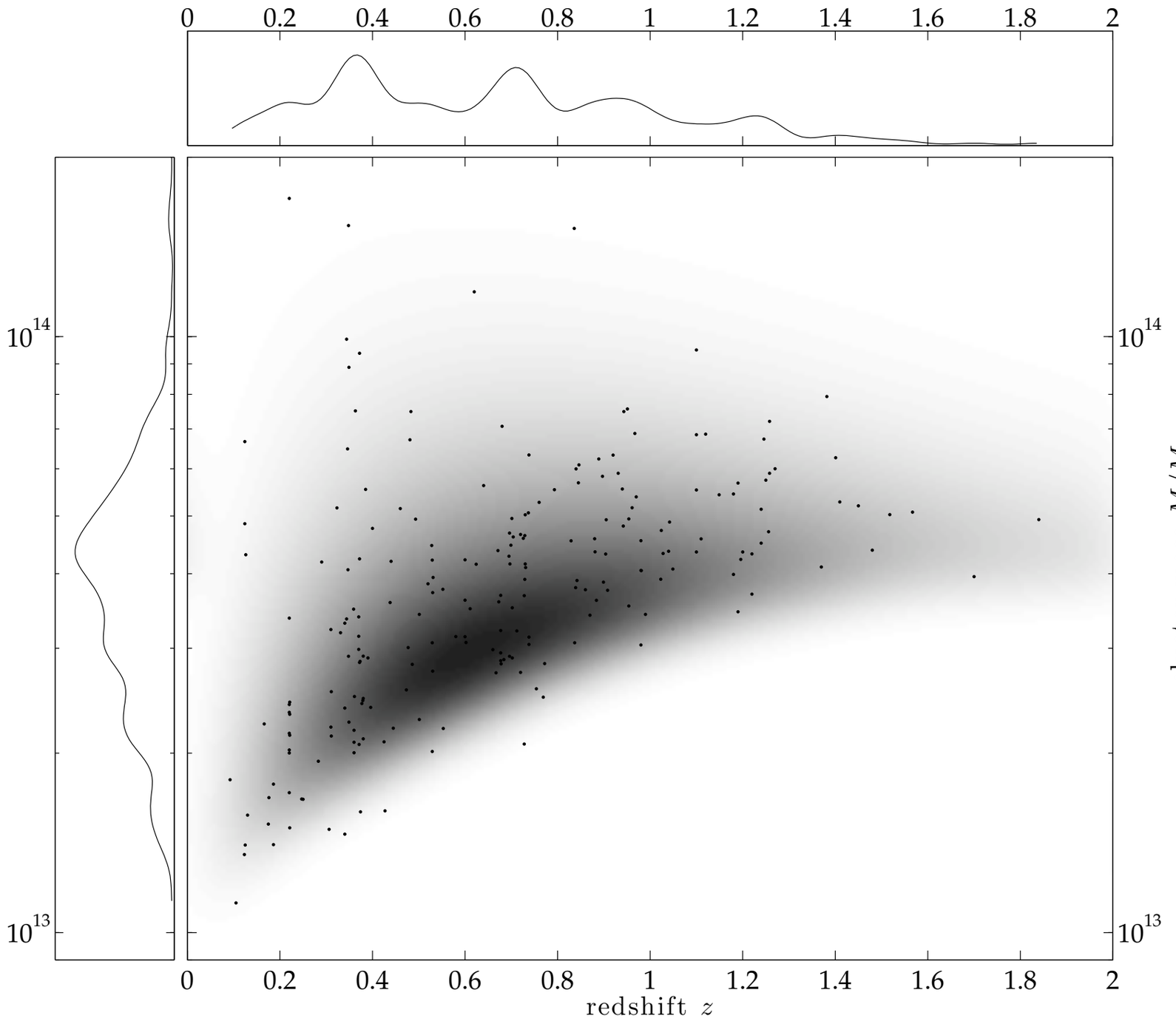


Clusters in the Cosmic Evolution Survey

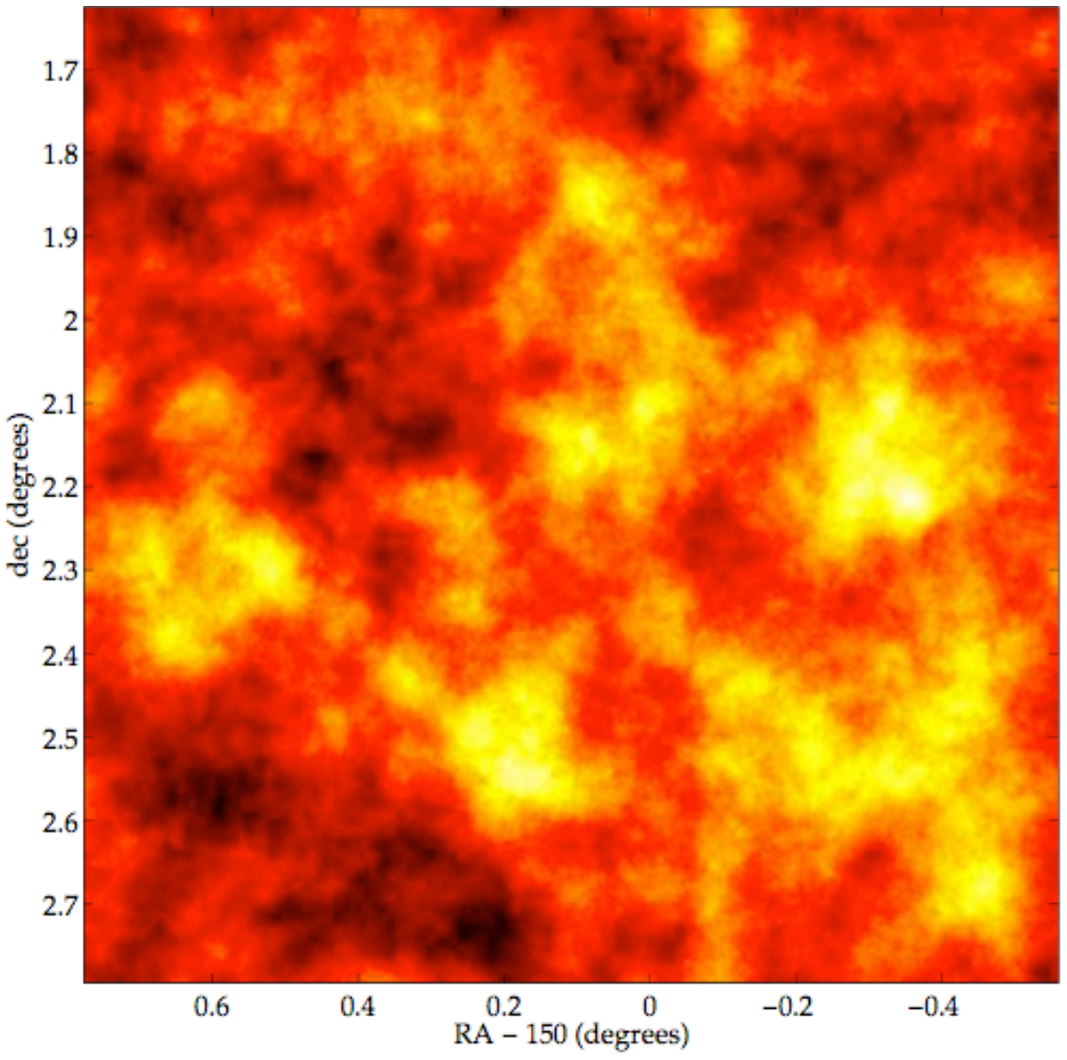


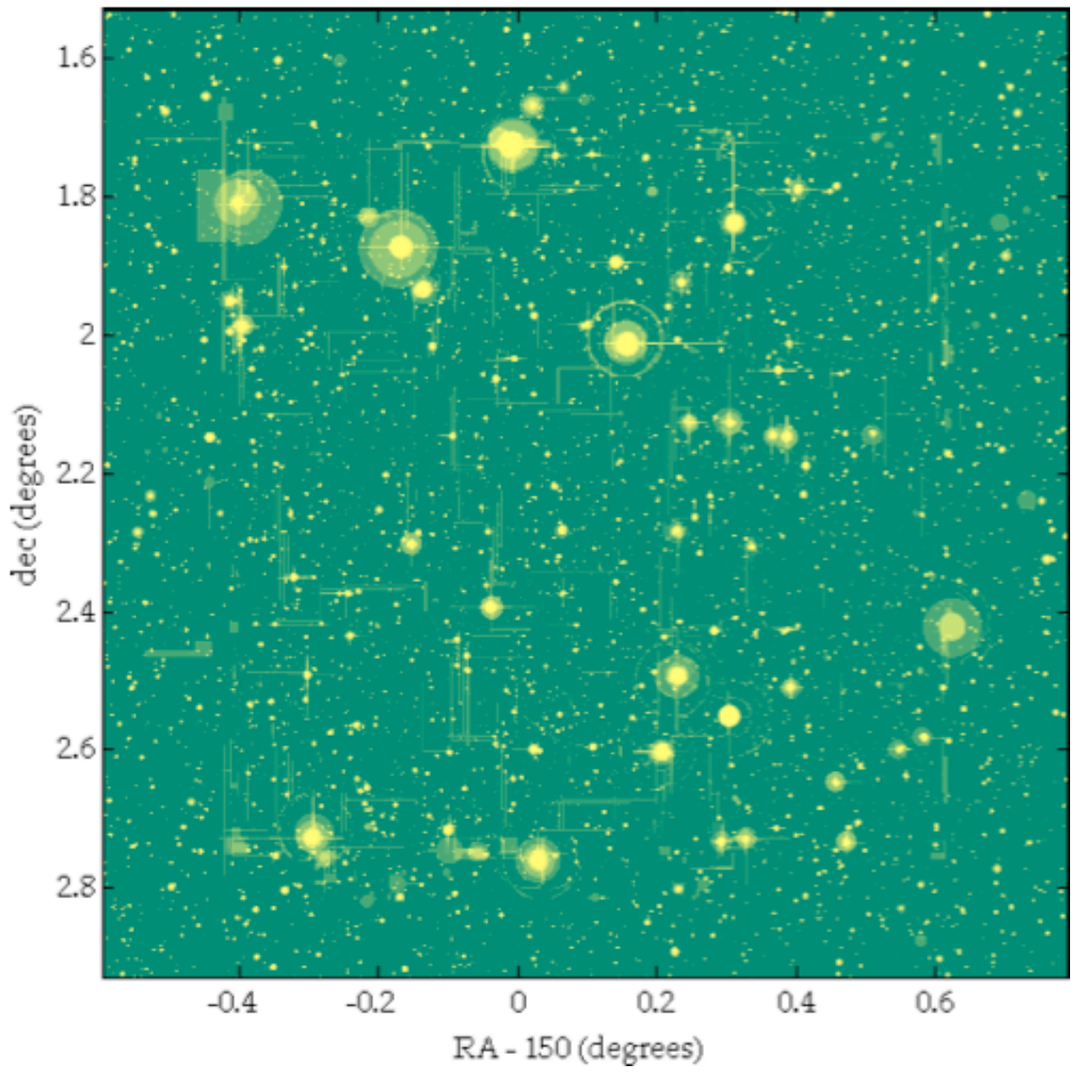


Cluster mass-redshift plane

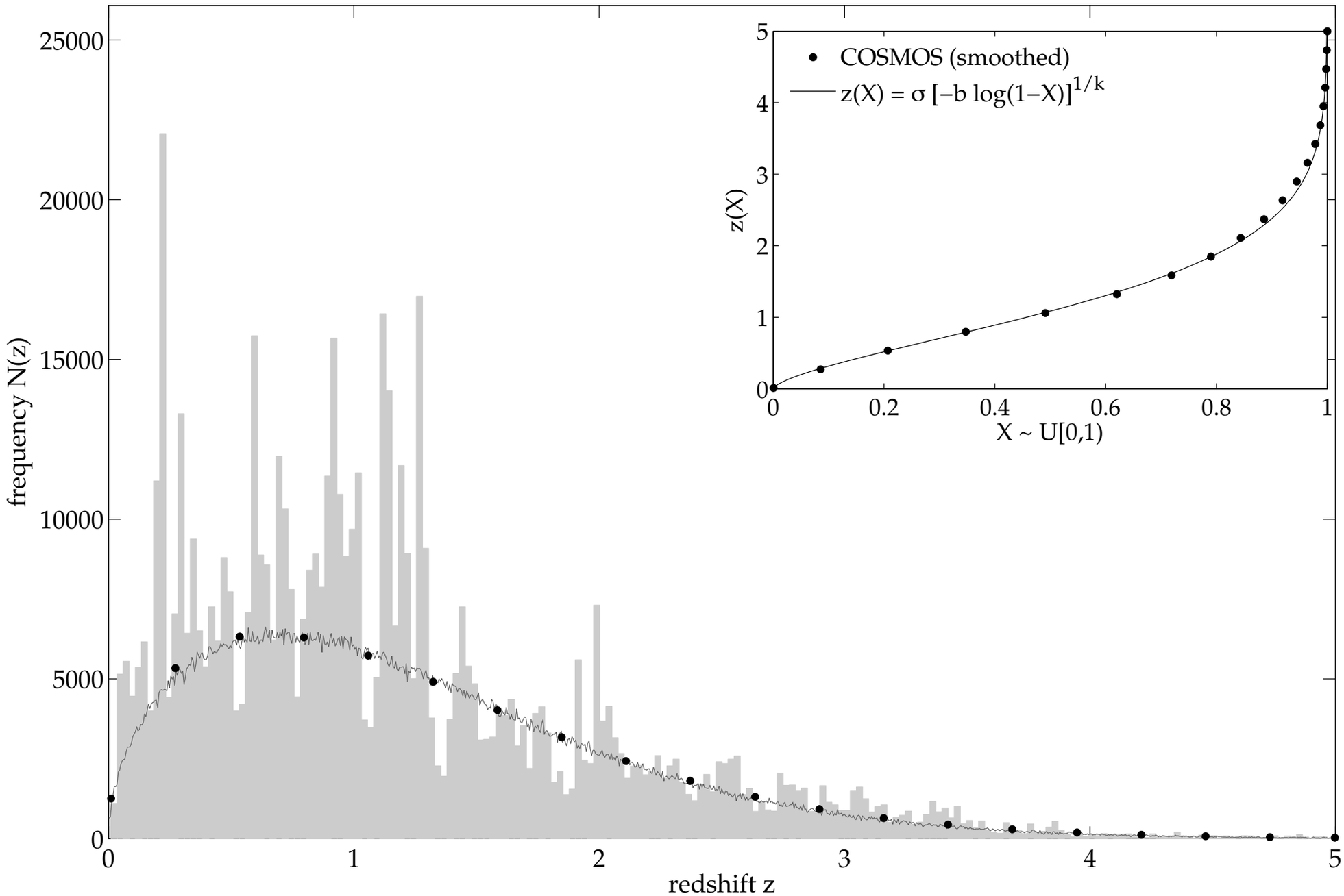


Galaxies in the Cosmic Evolution Survey





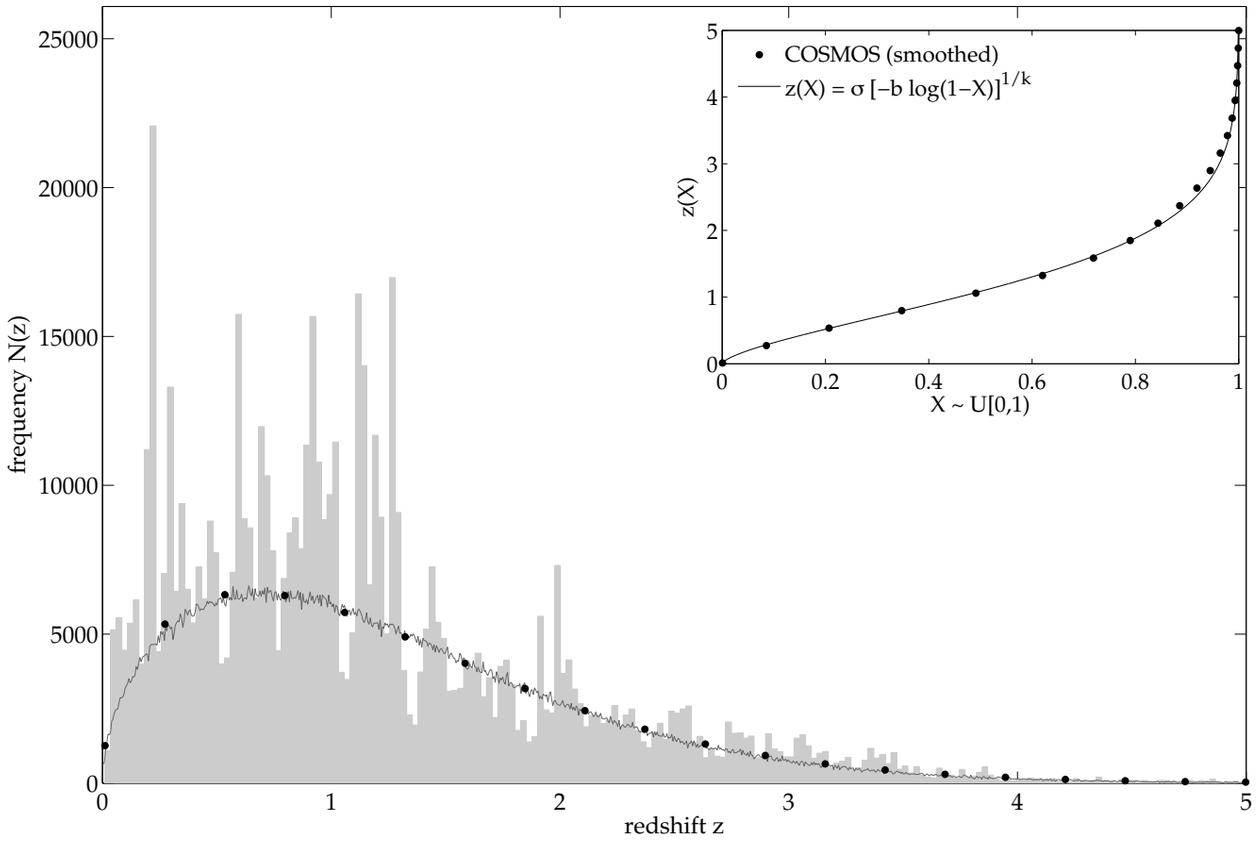
Fitting the redshift distribution of galaxies



Fitting the redshift distribution of galaxies

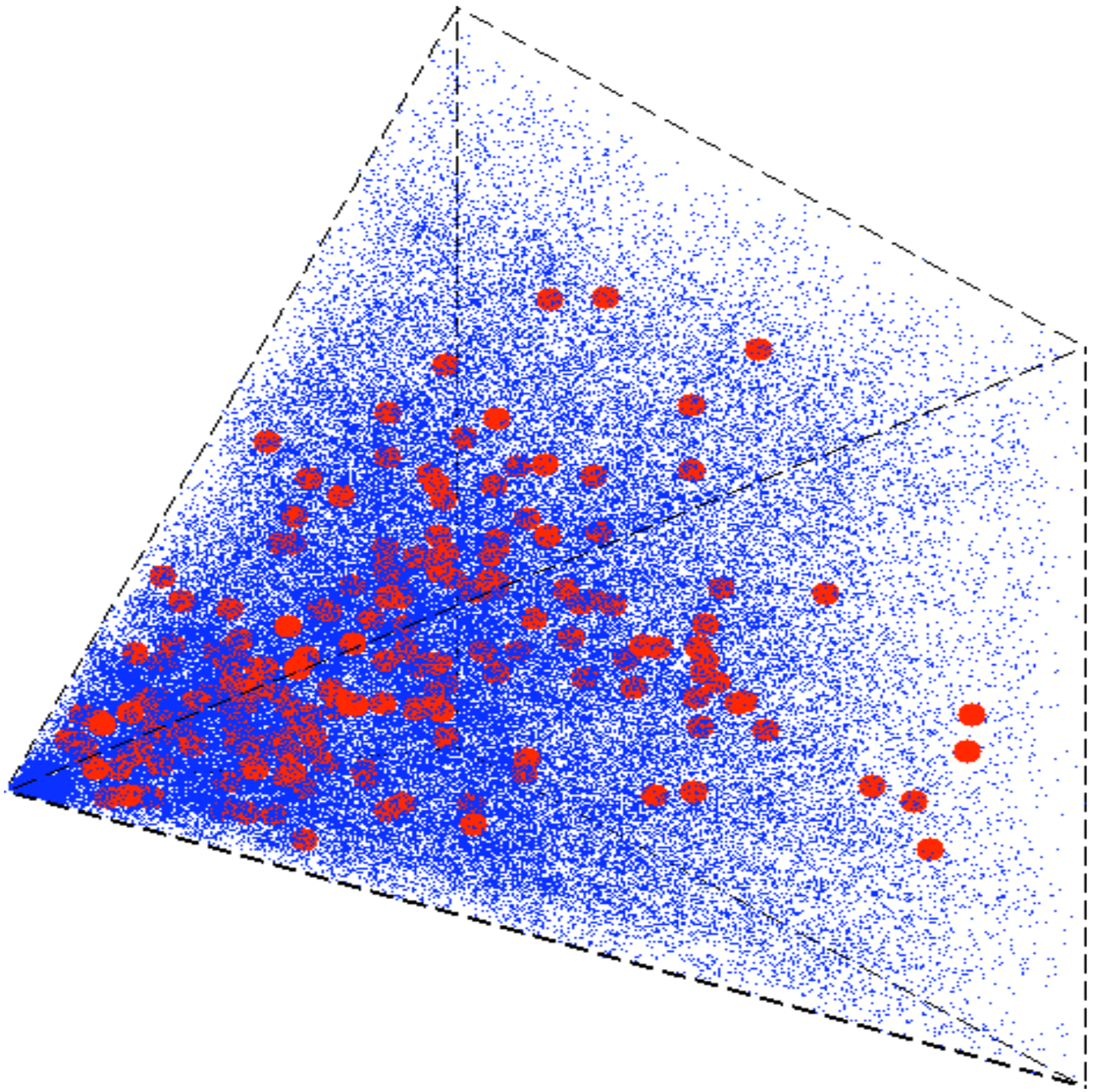
$$n(z) = z^{\alpha} \exp\left[-\left(\frac{z}{z_c}\right)^{\beta}\right]$$

$$X \sim U[0,1)$$

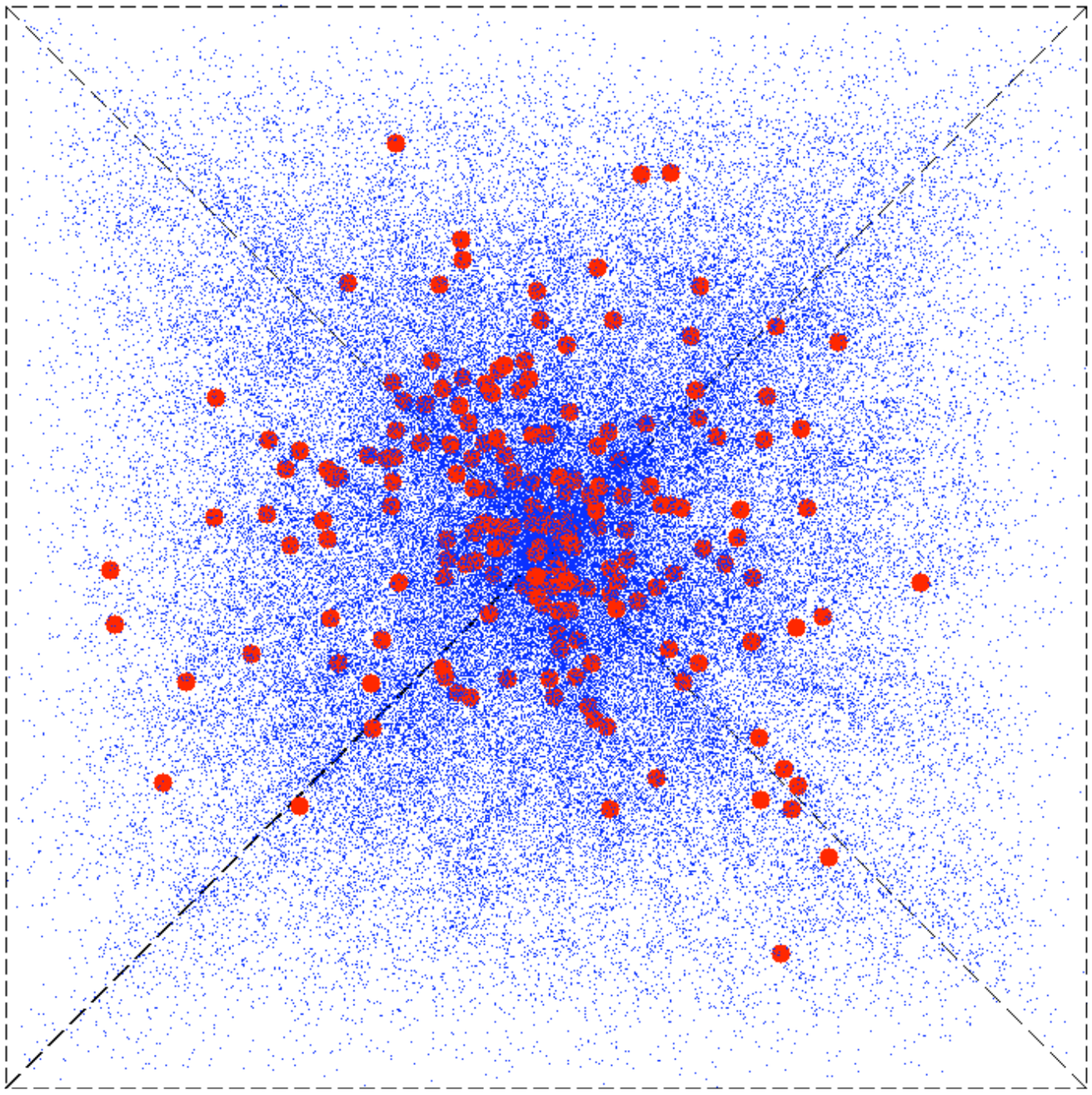


$$z(X) = \sigma\left[-b\log(1-X)\right]^{1/k}$$

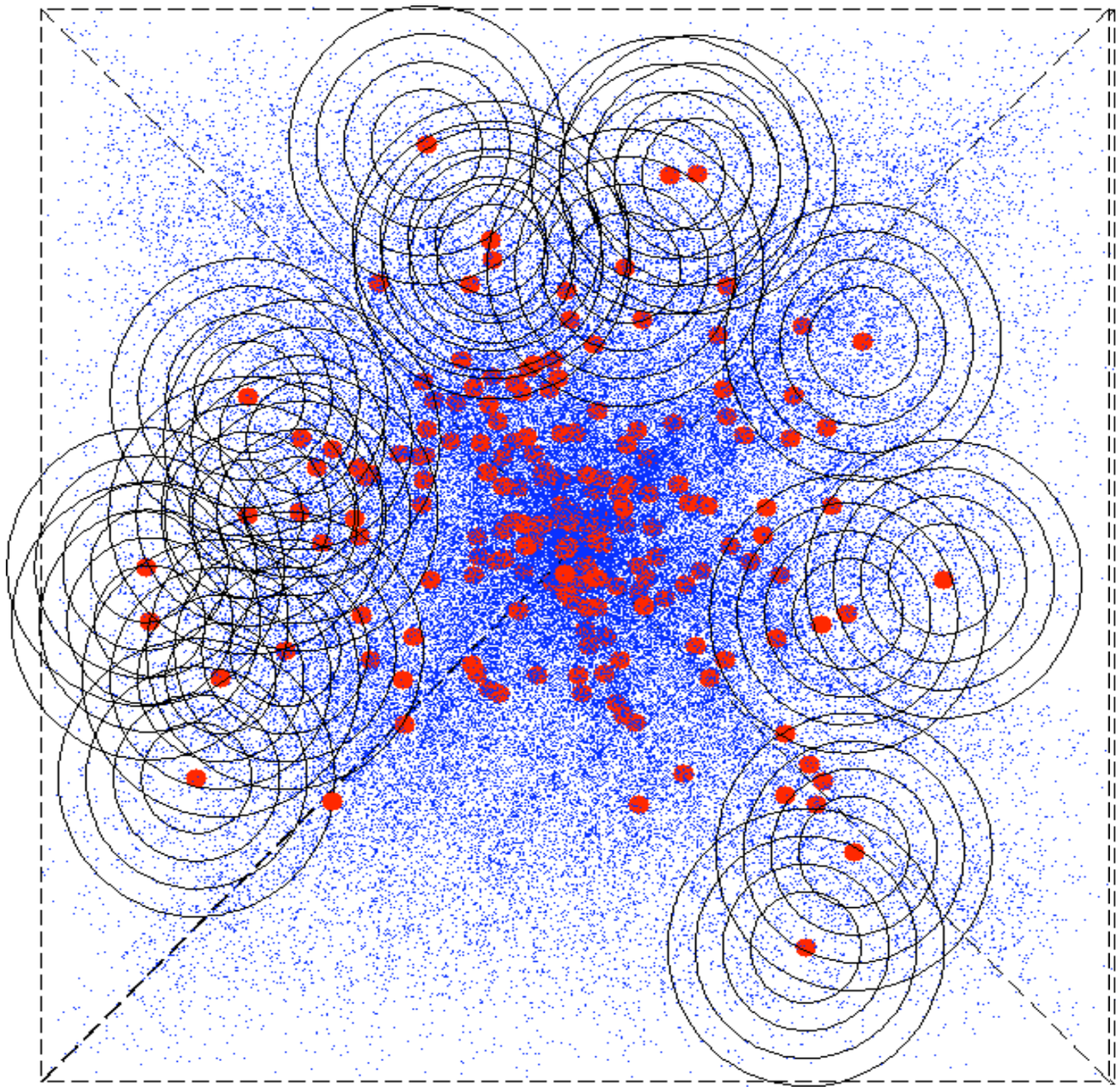
Cluster-galaxy cross-correlation function



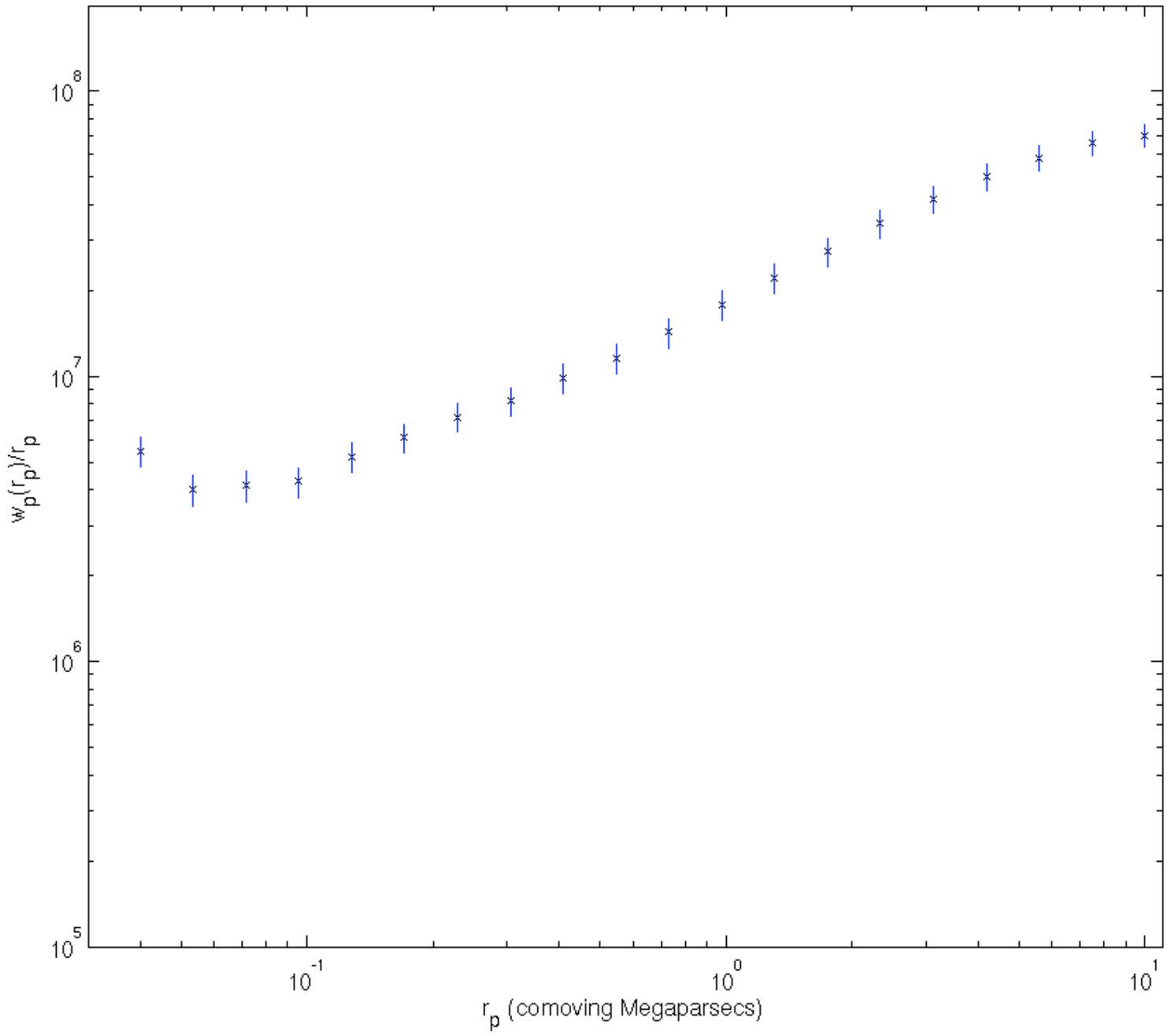
Distances between cluster-galaxy pairs



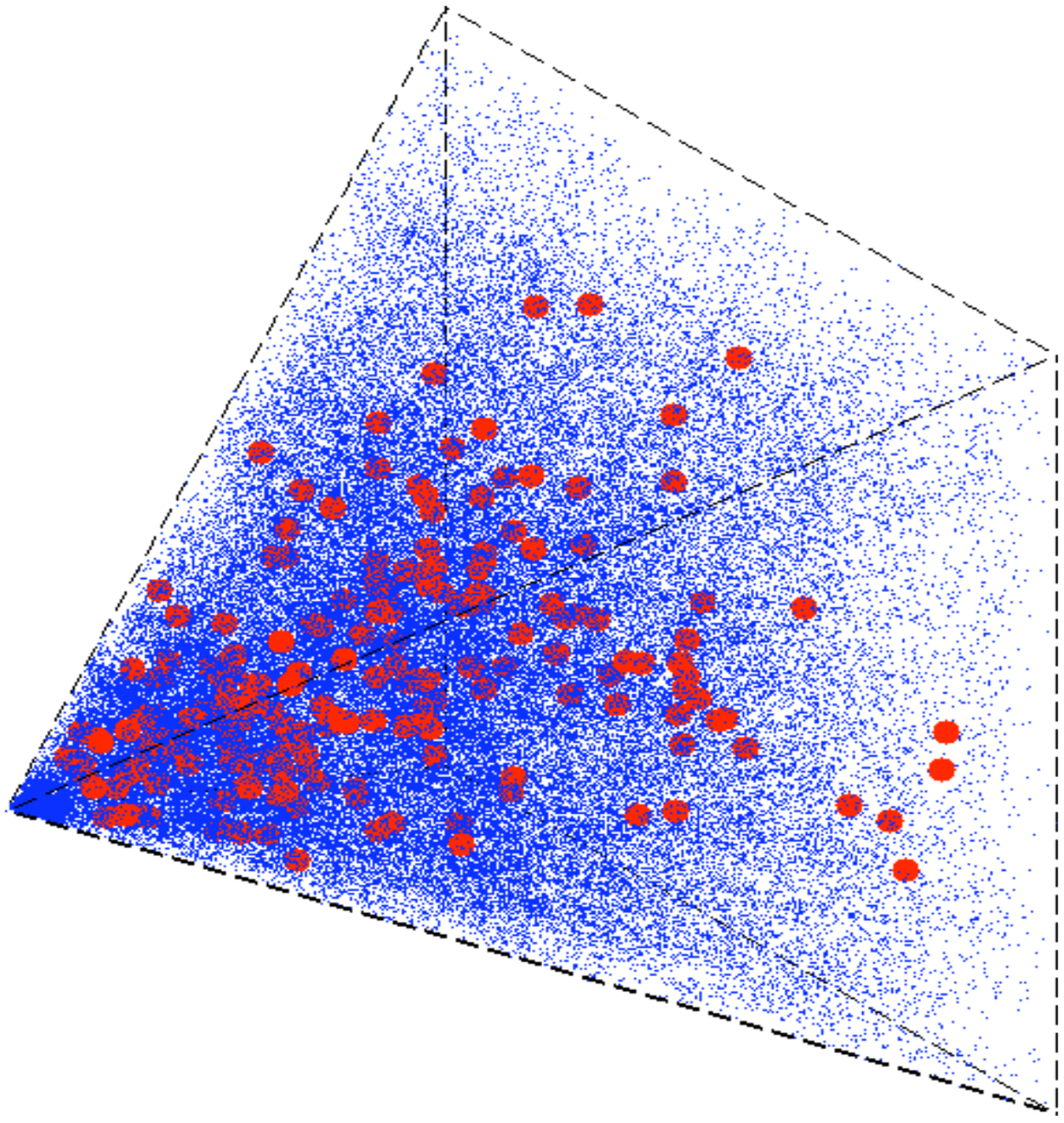
Distances between cluster-galaxy pairs

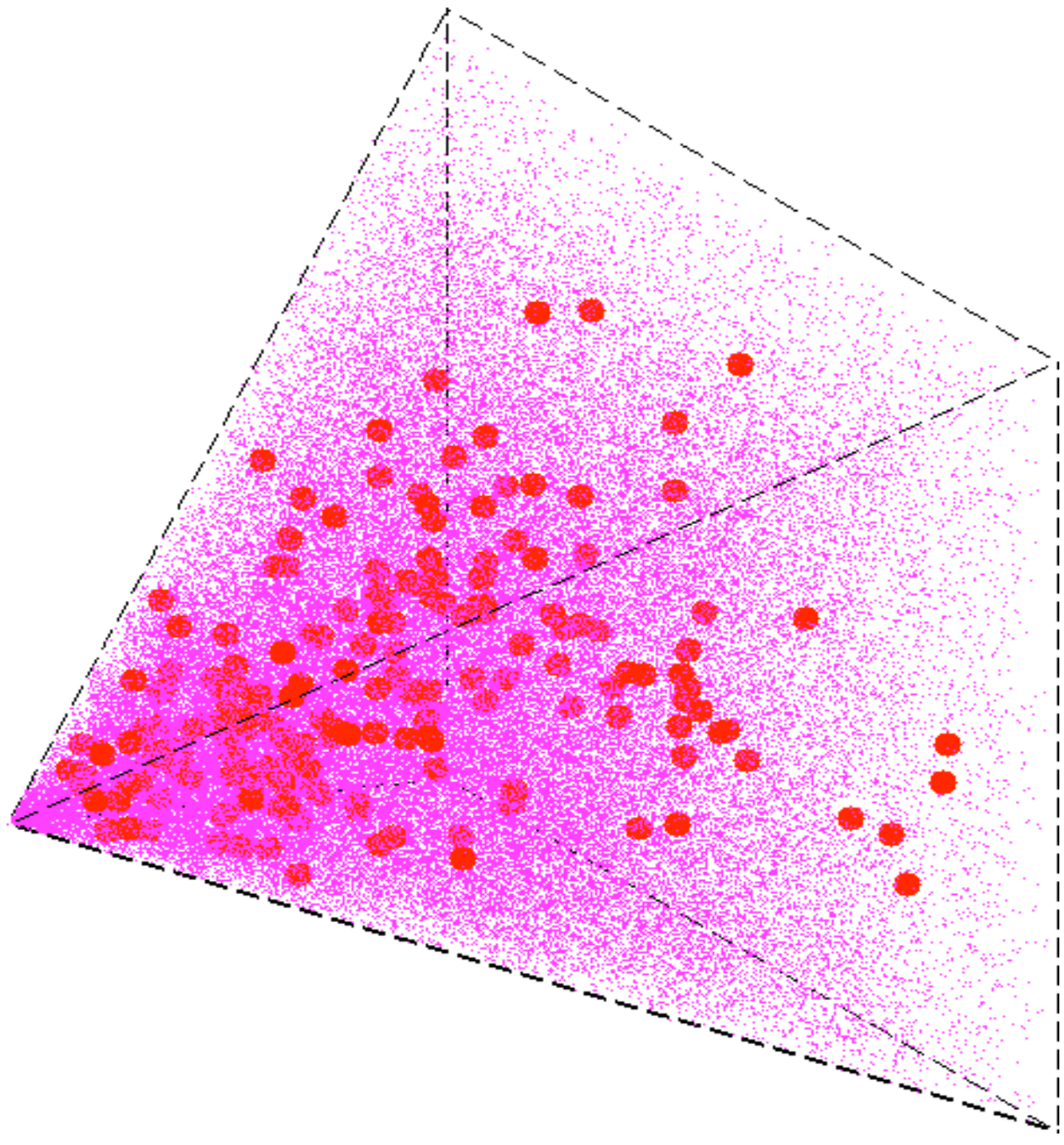


Distances between cluster-galaxy pairs

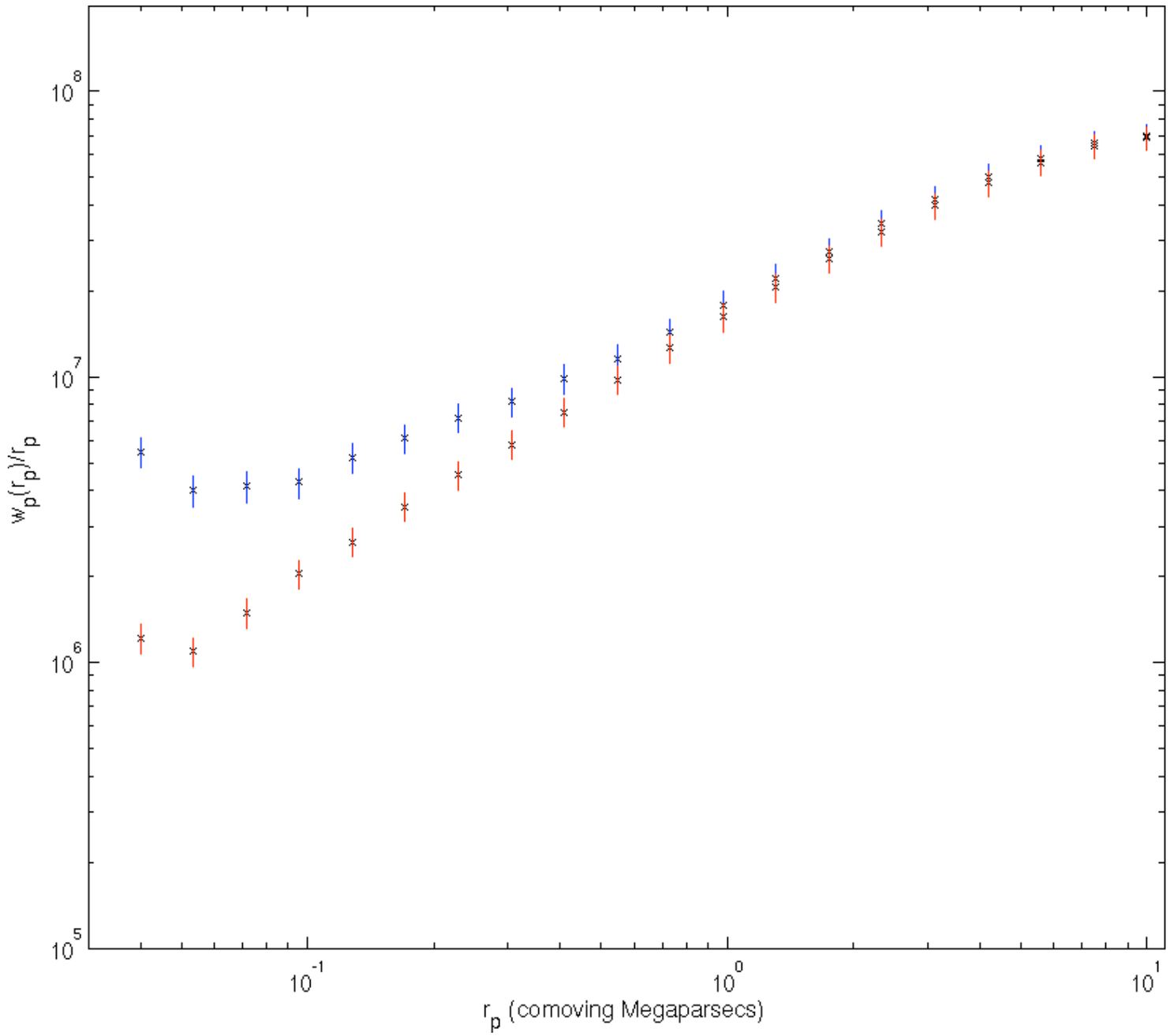


Distances between cluster-galaxy pairs

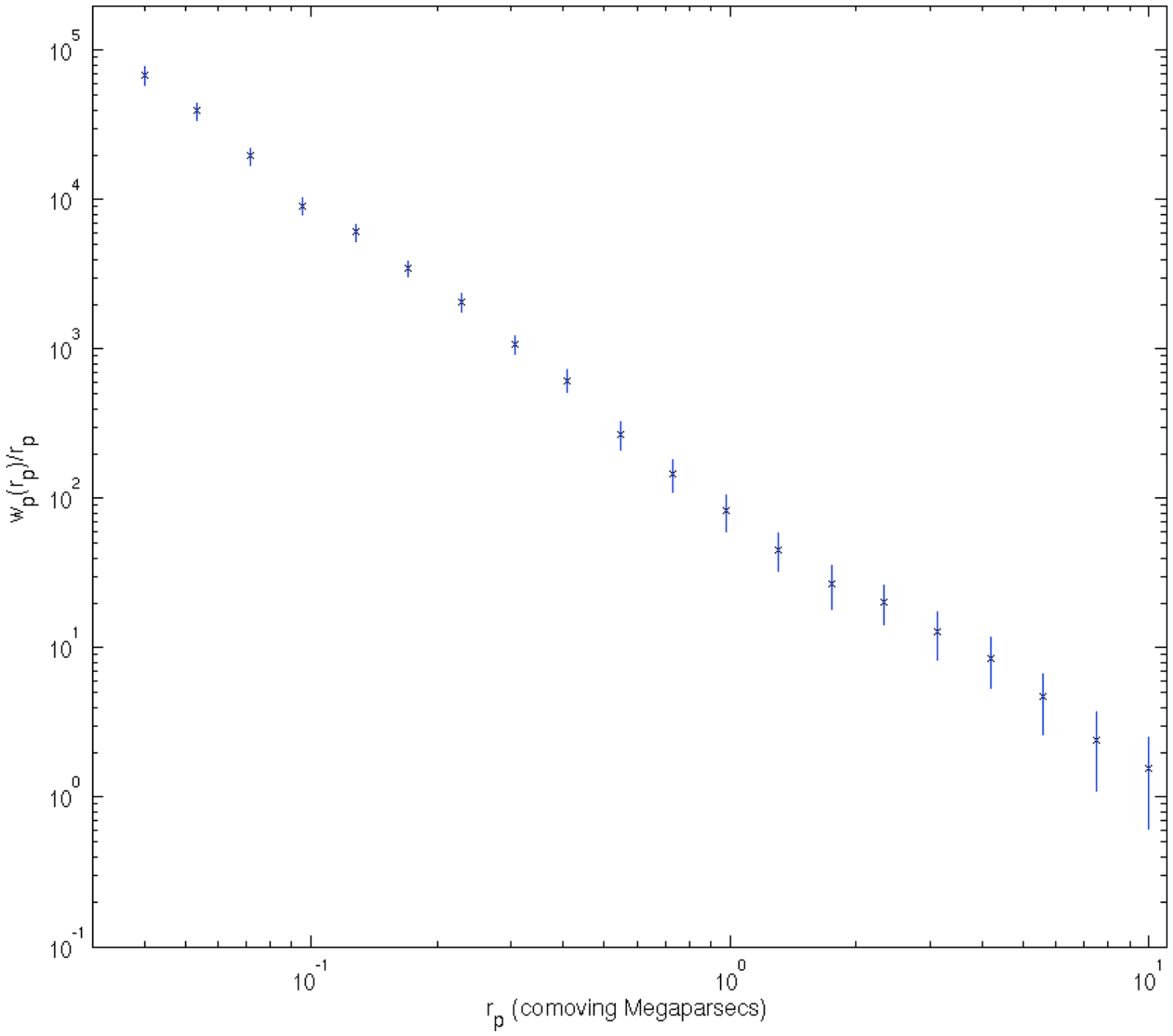




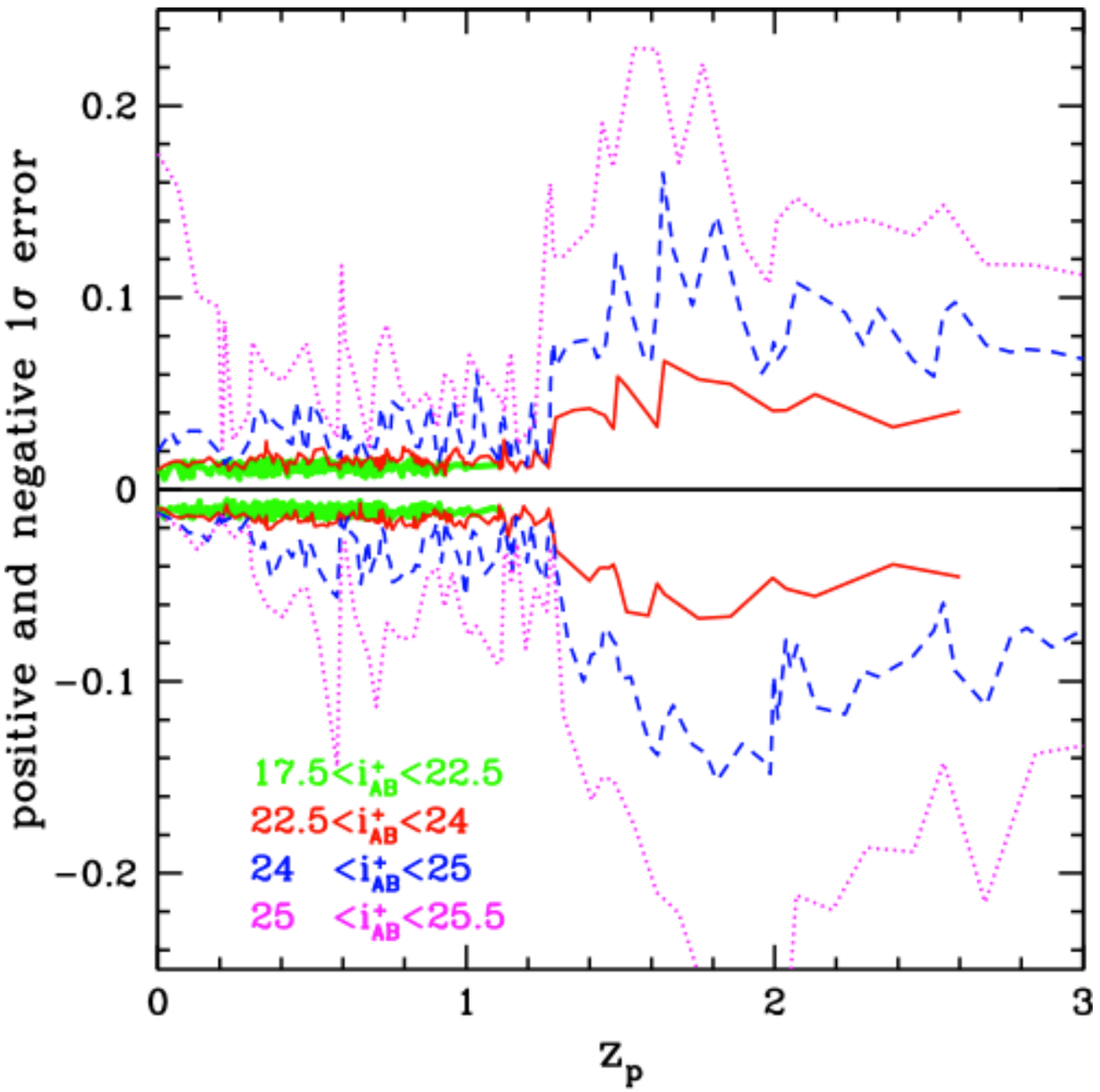
Distances between cluster-galaxy pairs



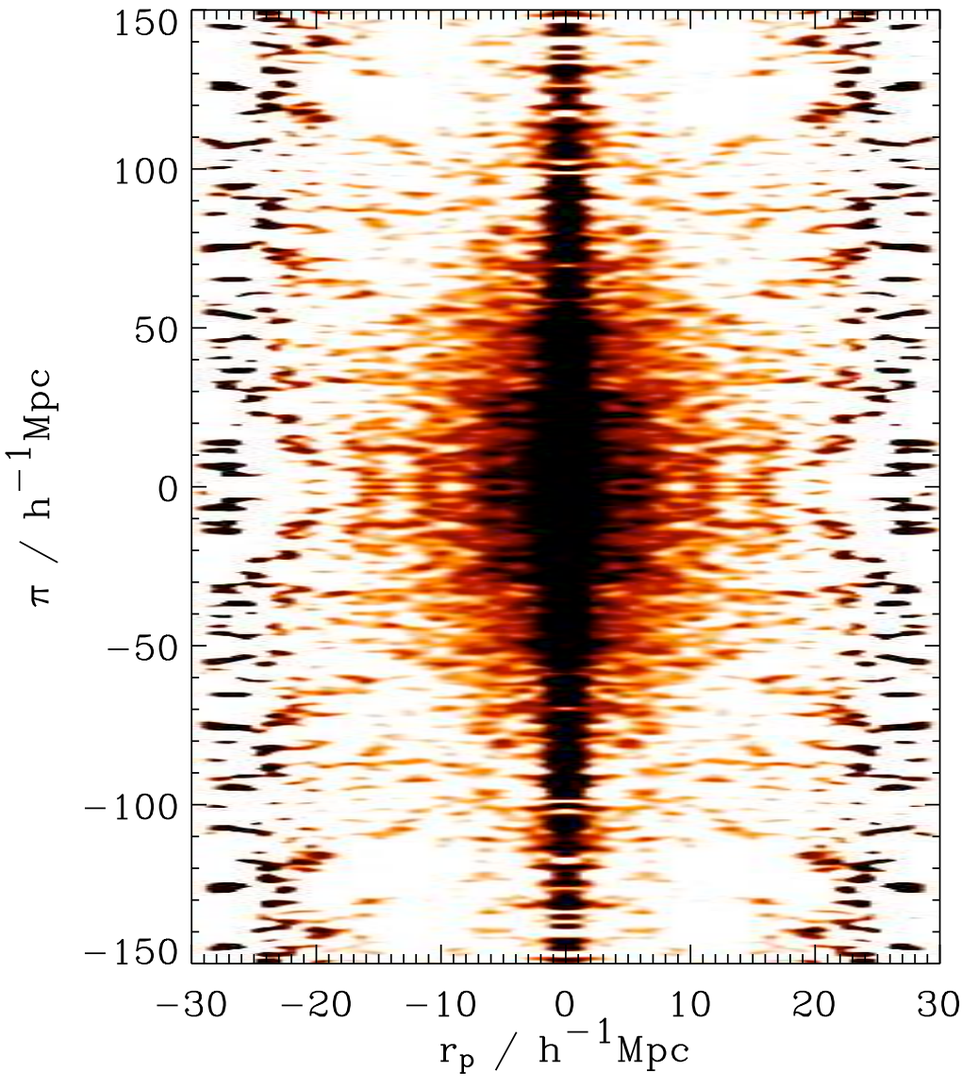
Distances between cluster-galaxy pairs



Use of projected correlation function

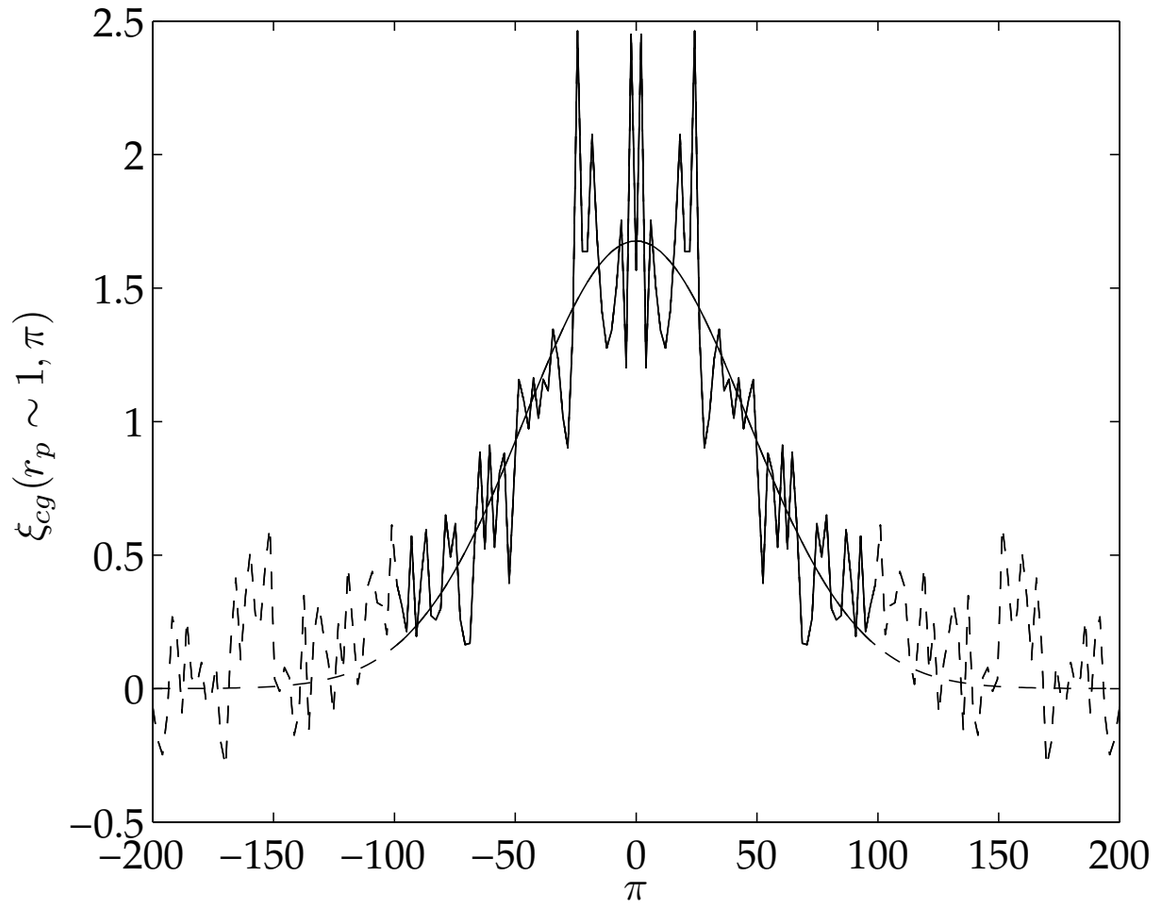


Ilbert et al. (2009) ApJ 690 1239



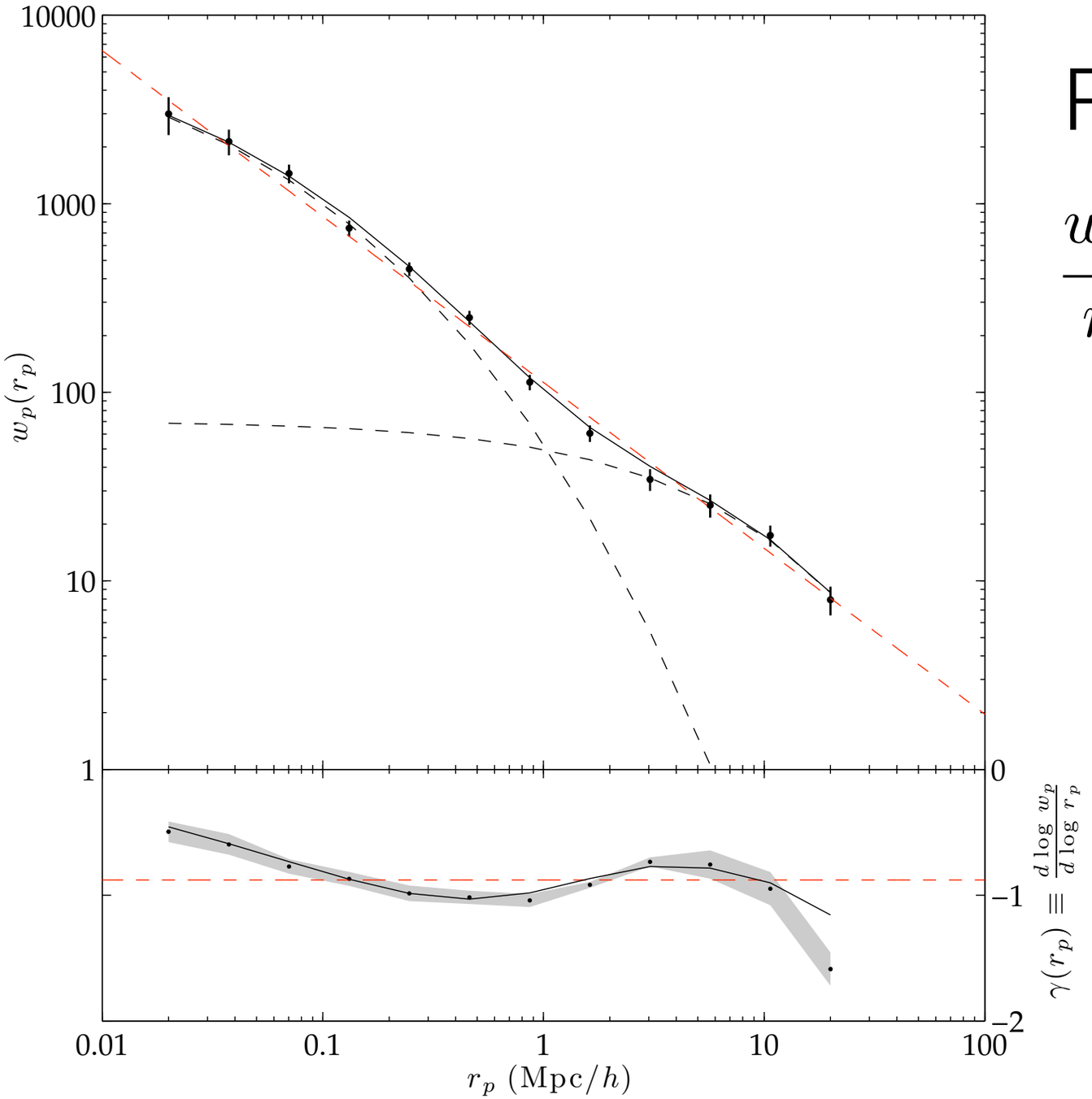
$$w_p(r_p) = 2\int_0^\infty \xi_{cg}^{\mathrm{LS}}(r_p,\pi)d\pi;$$

Projection of decomposed distribution



$$
\begin{aligned}
w_p(r_p) &= 2\int_0^{\pi_{\rm cut}} \xi_{cg}^{\rm LS}(r_p,\pi)d\pi + \\
&\quad 2\int_{\pi_{\rm cut}}^{\infty} A_\pi(r_p)\exp\left[-\frac{\pi^2}{2\sigma_\pi(r_p)^2}\right]d\pi \\
&= w_p(r_p)_{\rm cut} + 2A_\pi(r_p){\rm erf}_c\left(\frac{\pi_{\rm cut}}{\sigma_\pi(r_p)\sqrt{2}}\right)
\end{aligned}
$$

Projected cross-correlation function

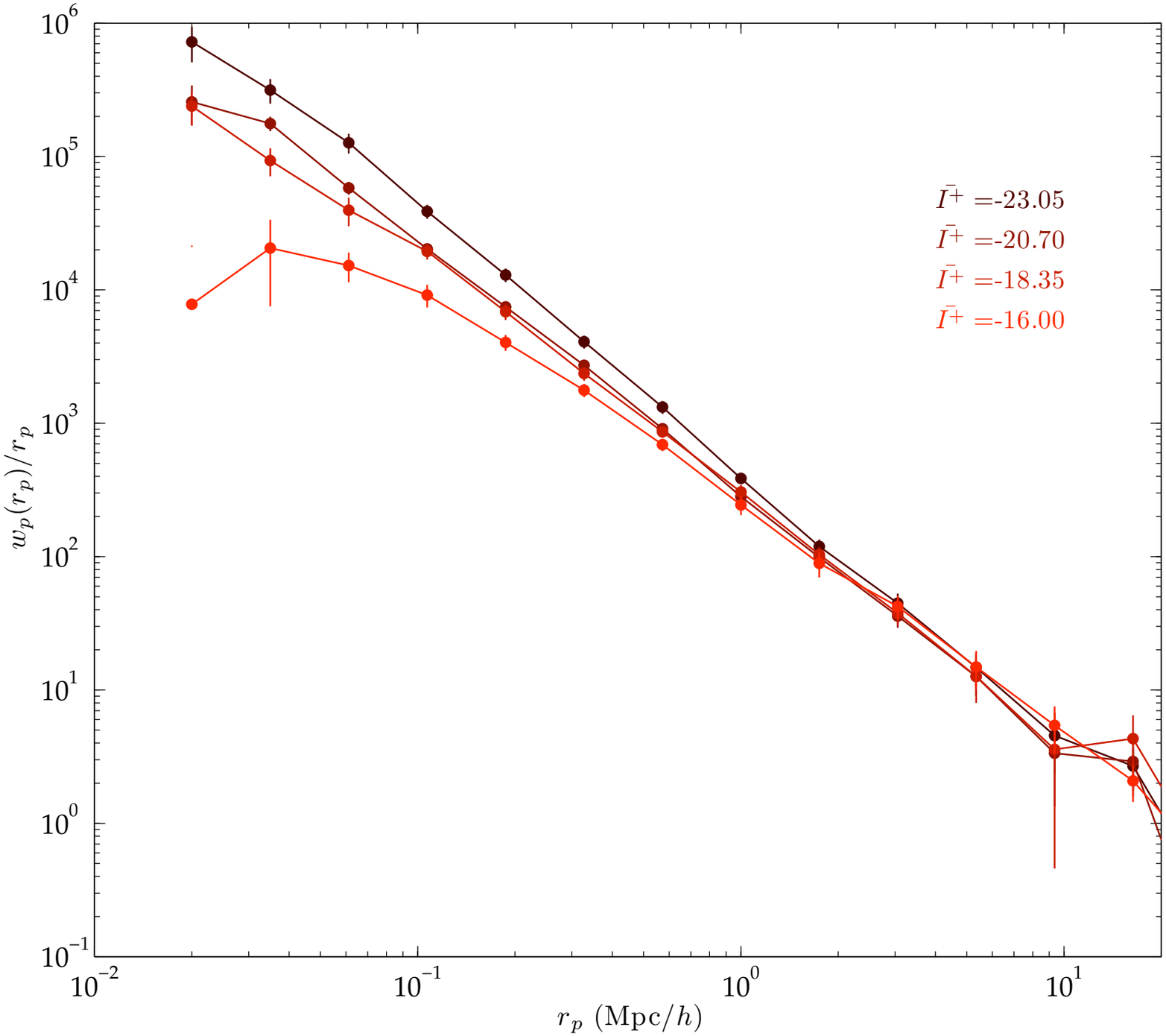


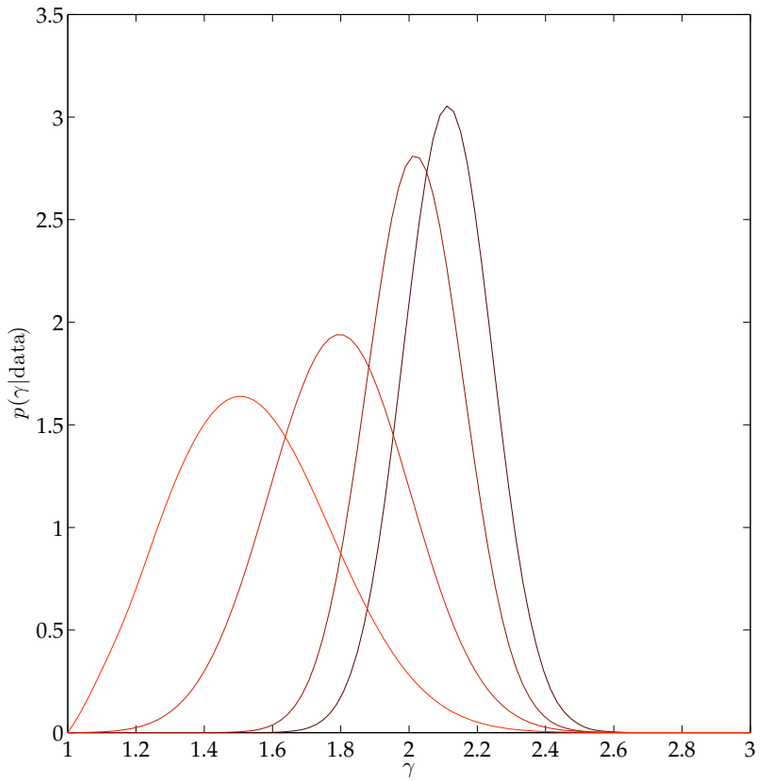
Power law

$$\frac{w_p^m}{r_p} = \frac{\Gamma\left(\frac{1}{2}\right)\Gamma\left(\frac{\gamma-1}{2}\right)}{\Gamma\left(\frac{\gamma}{2}\right)}\left(\frac{r_p}{r_0}\right)^{-\gamma}$$

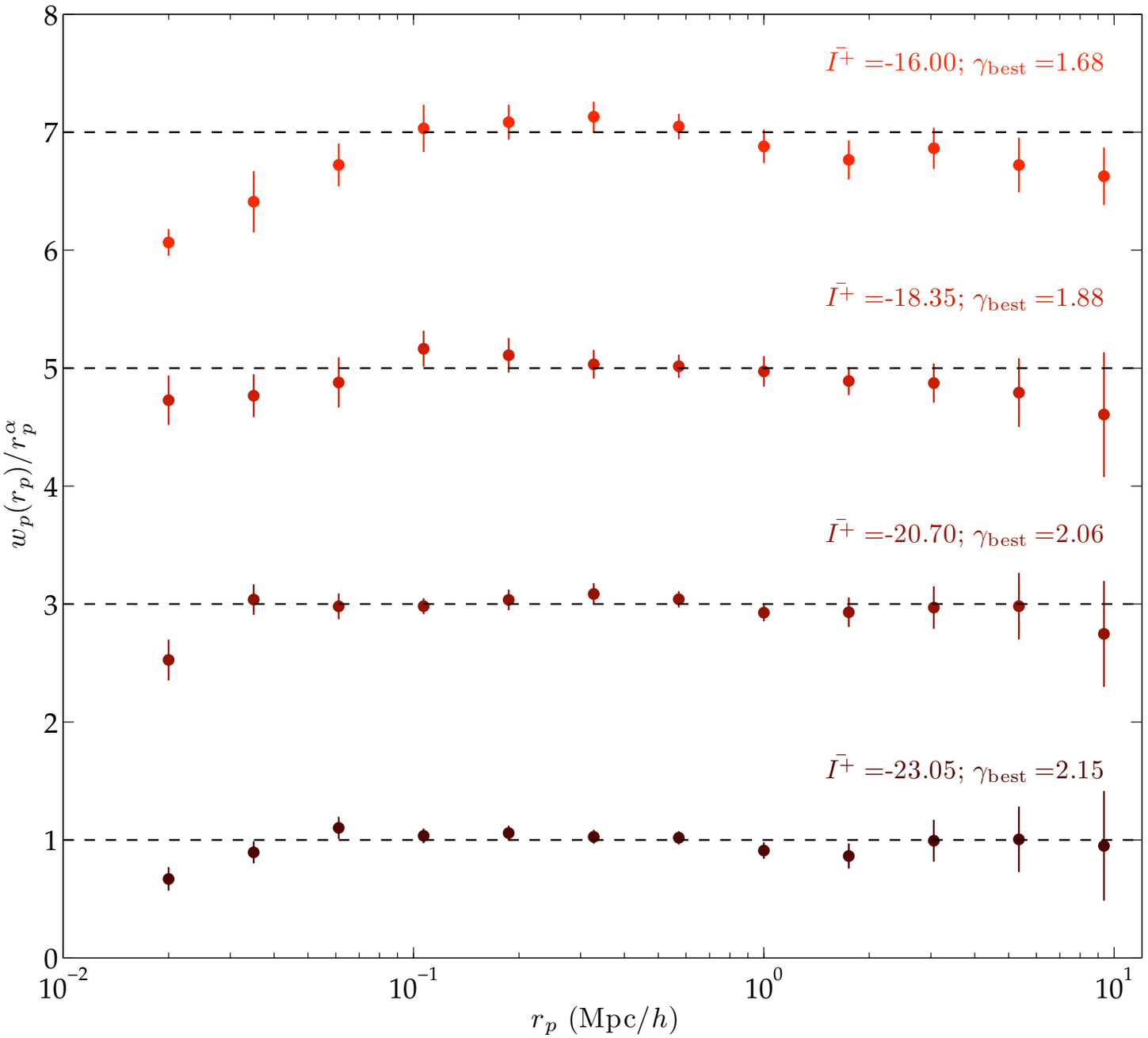
$$\gamma(r_p) \equiv \frac{d\log w_p}{d\log r_p}$$

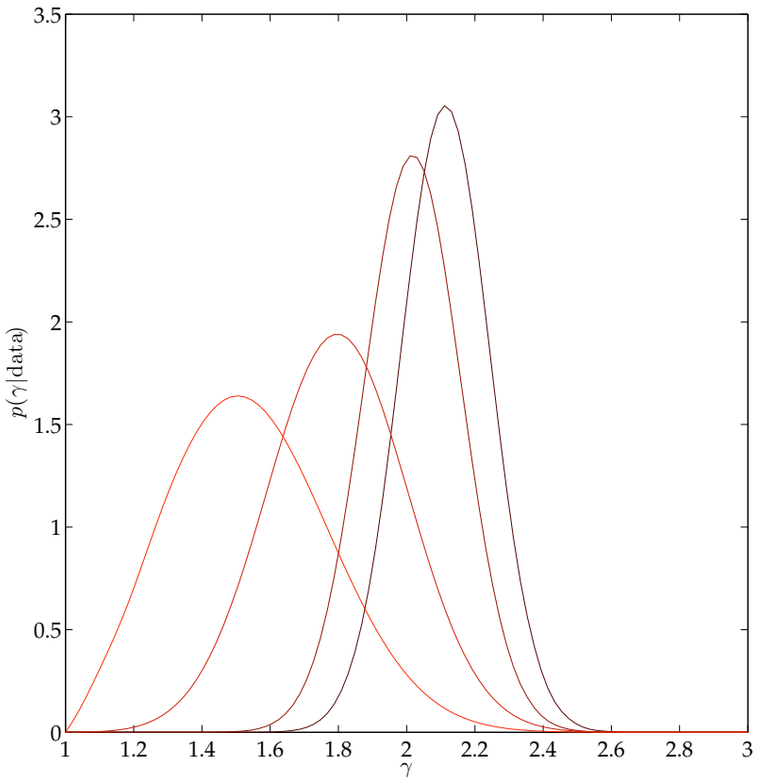
Compactness of the galaxy distribution



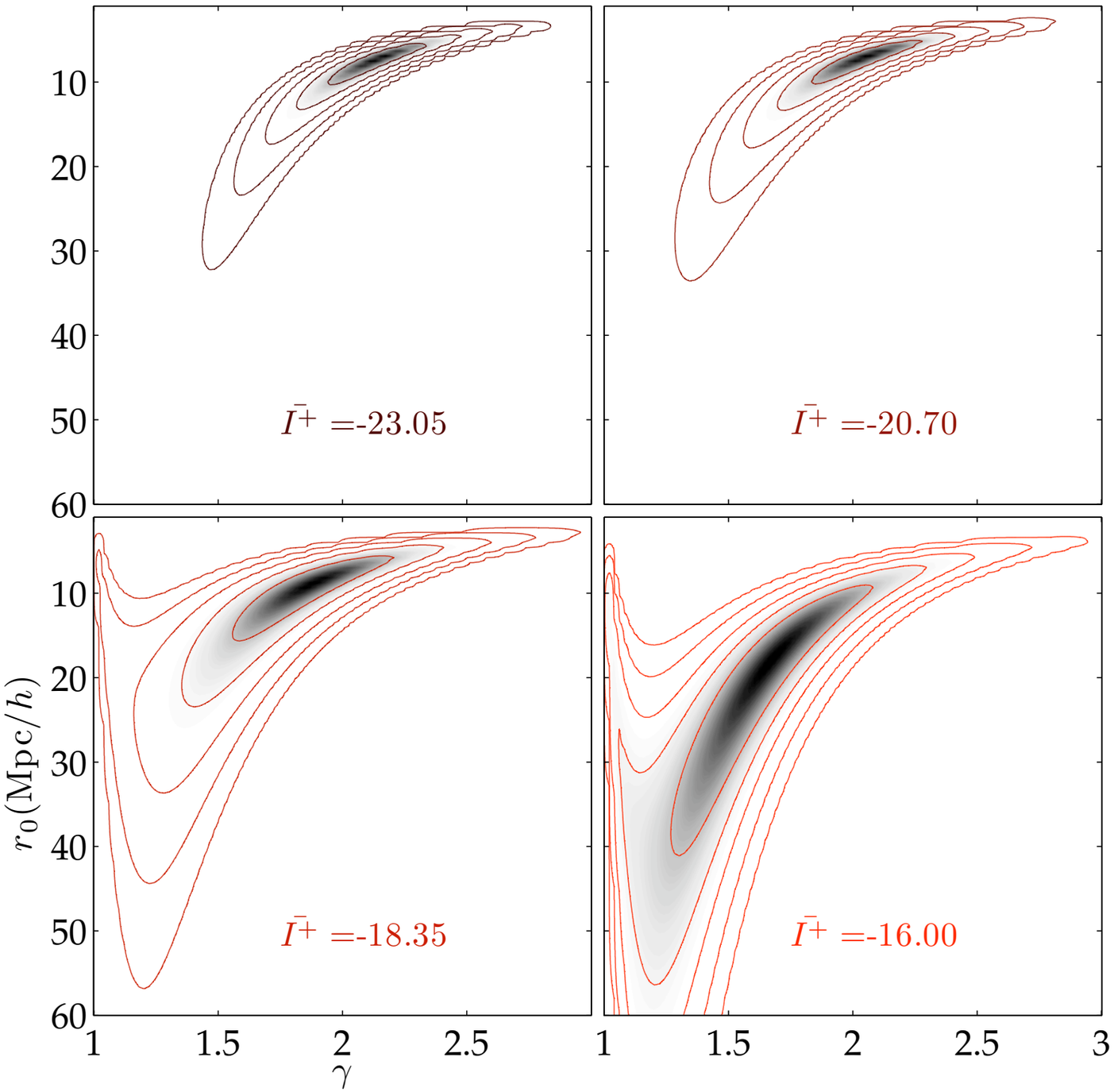


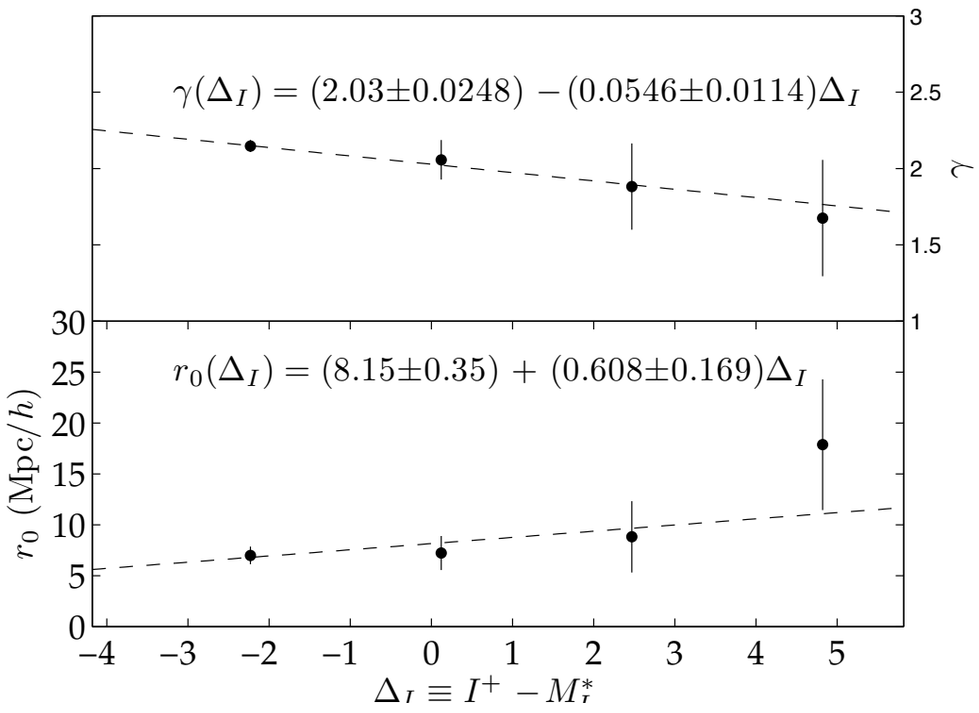
Compactness of the galaxy distribution, ctd.



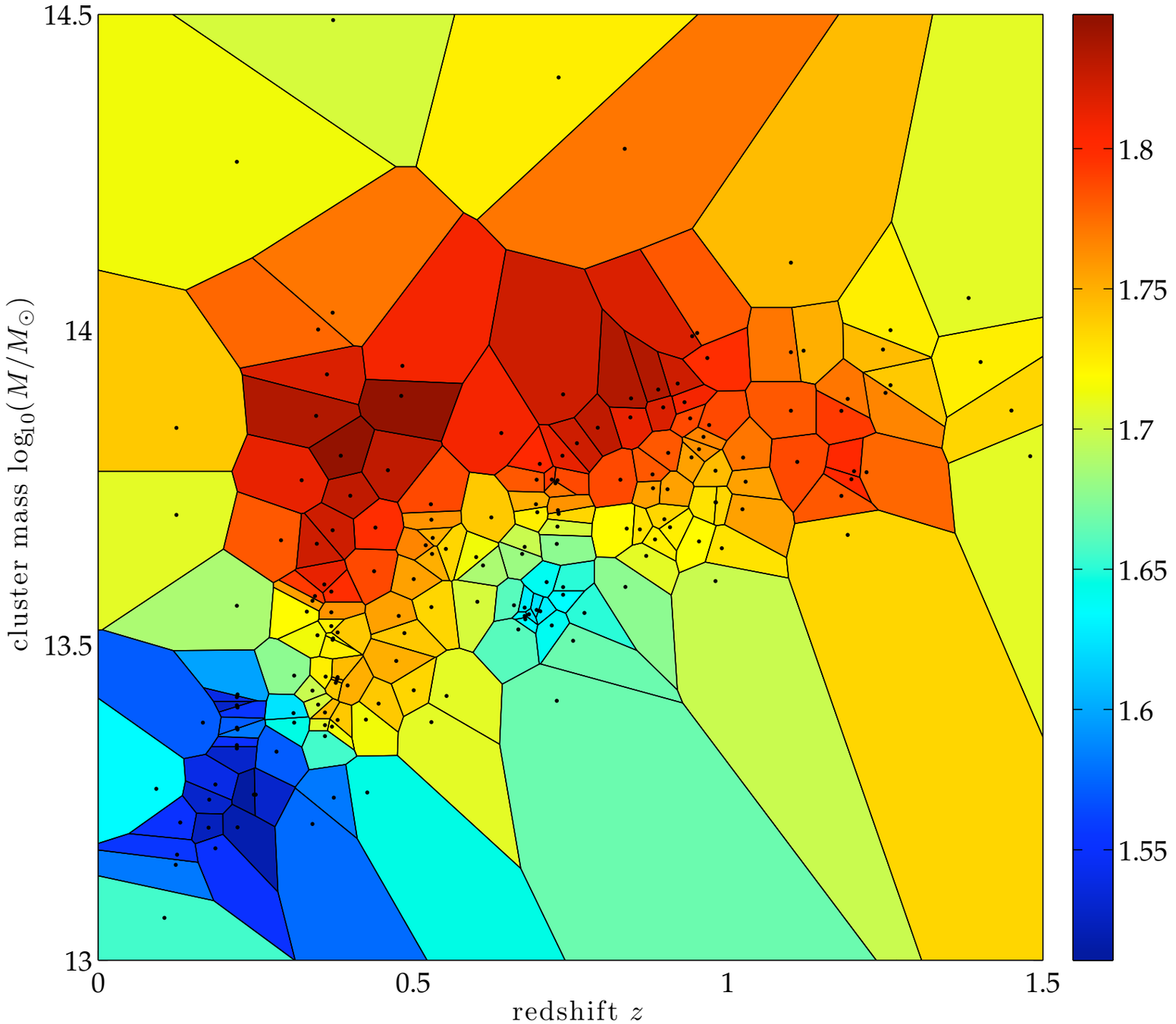


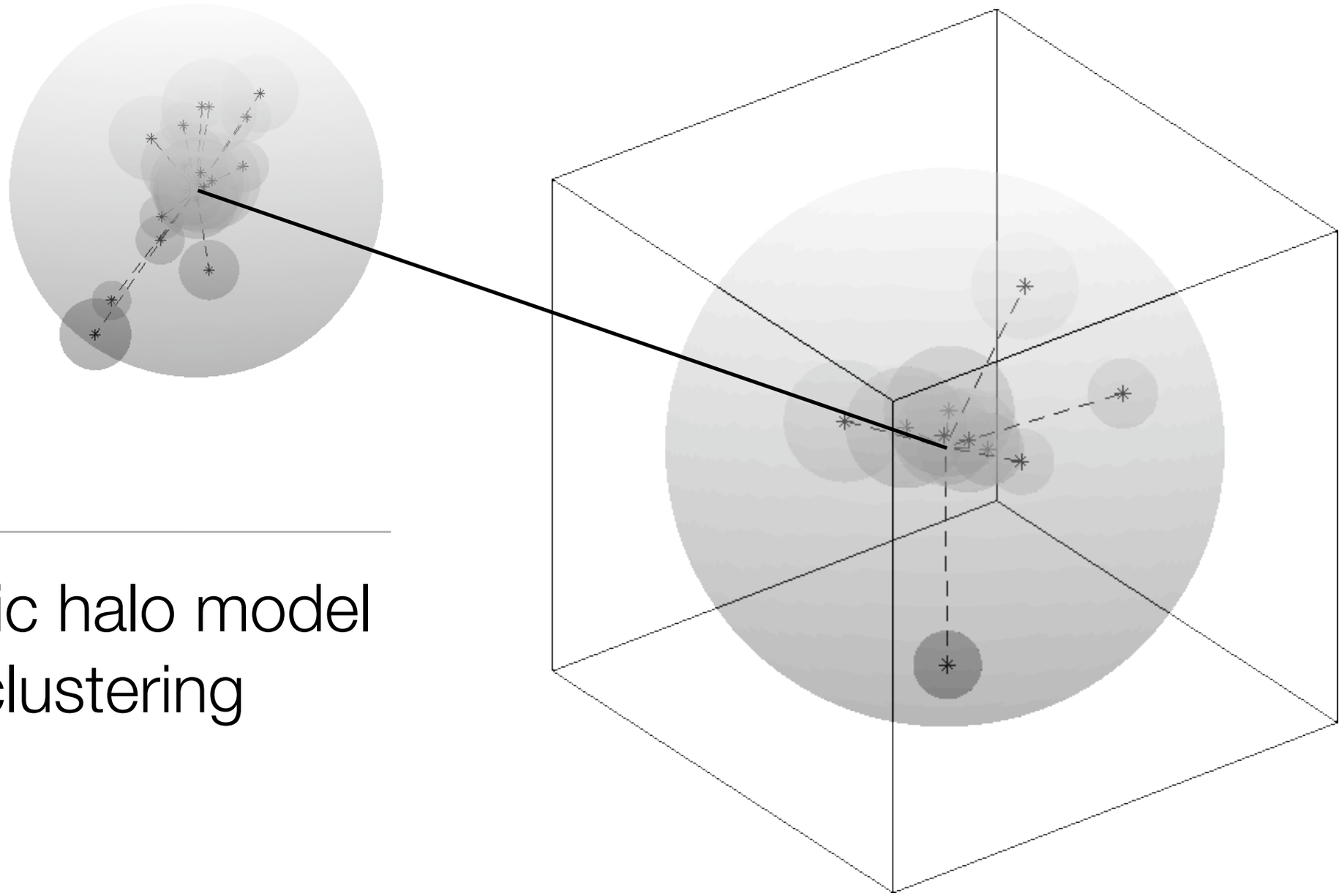
Compactness of the galaxy distribution, ctd.





Is it possible to partition a metric-less plane?

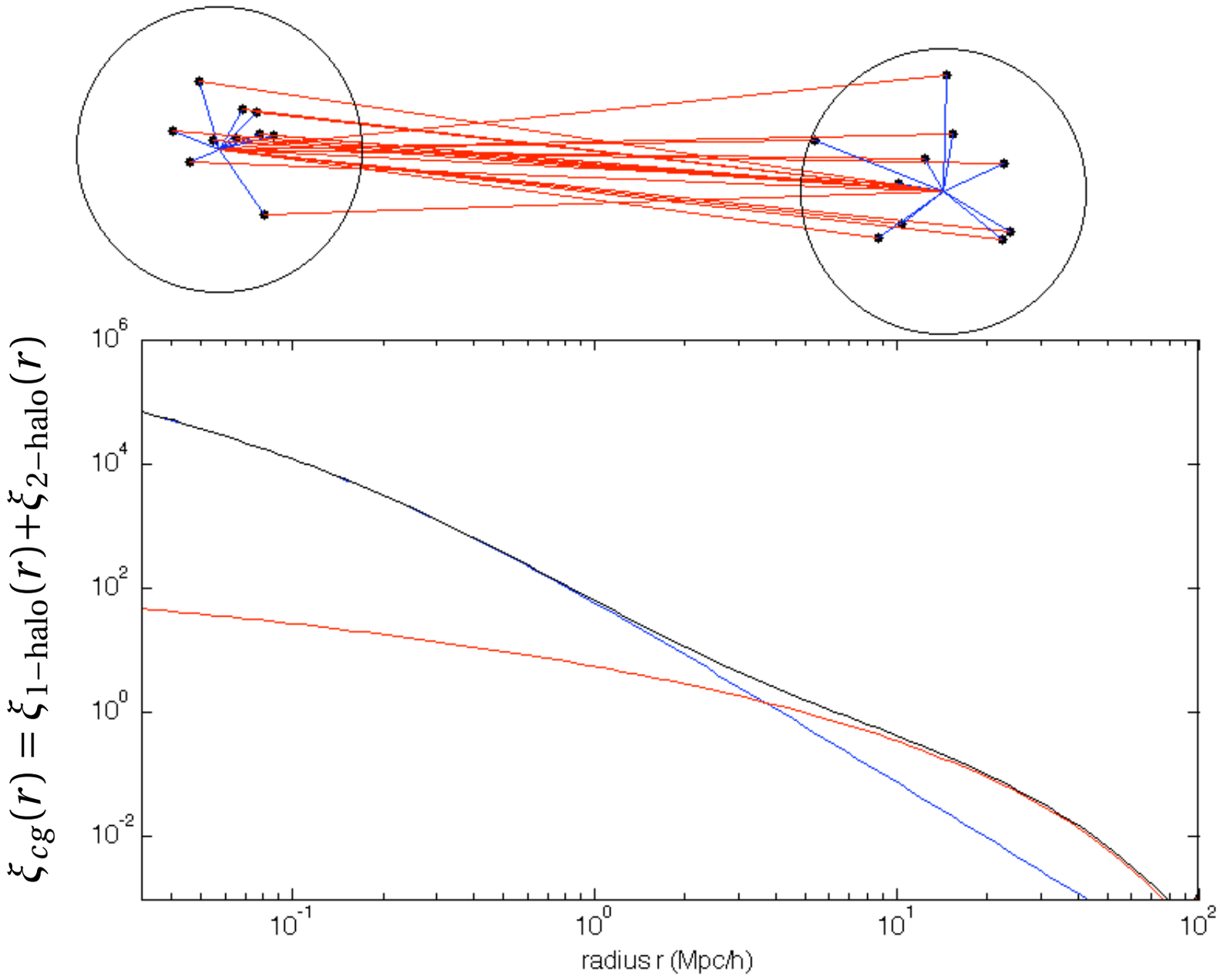




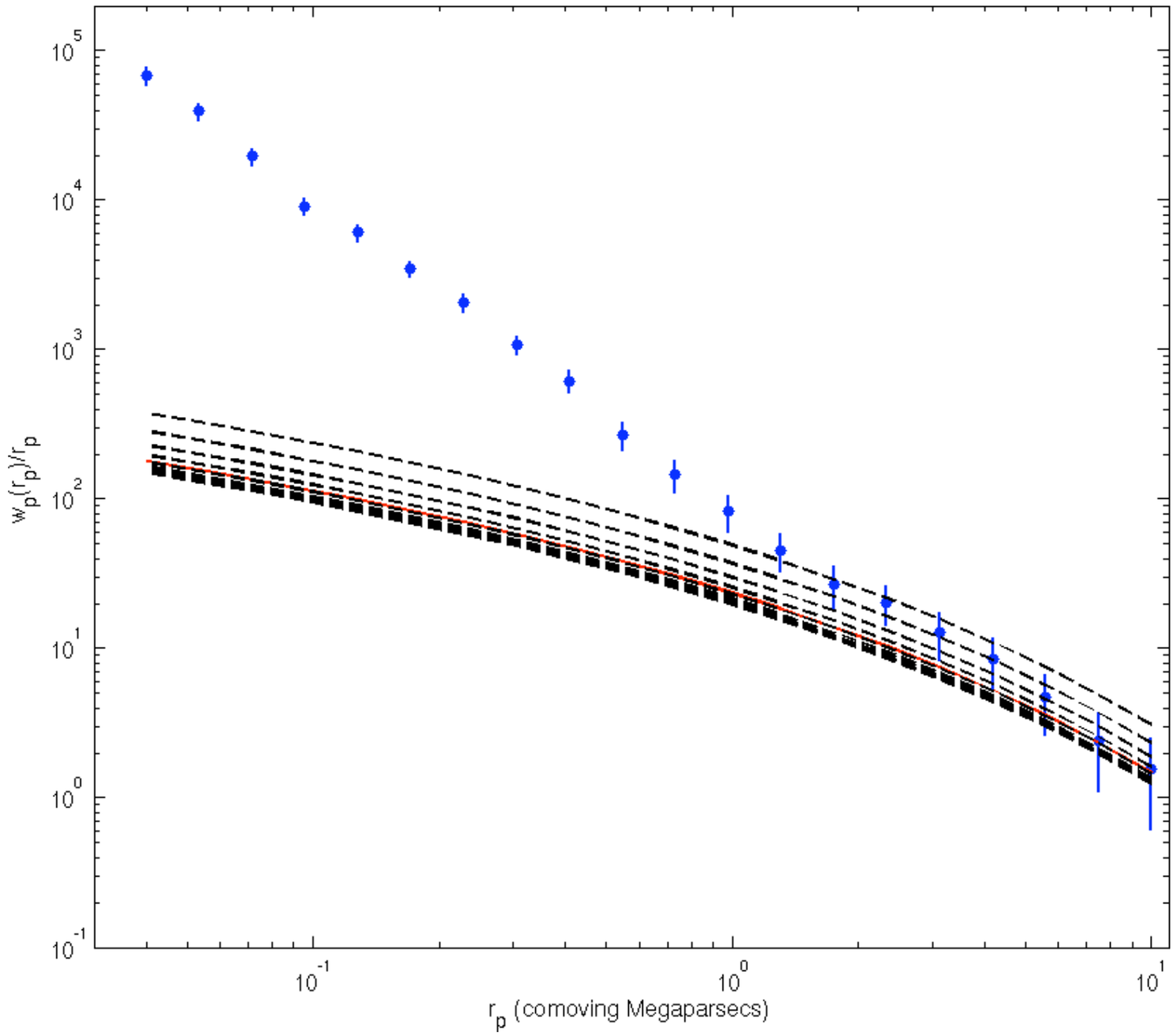
Two

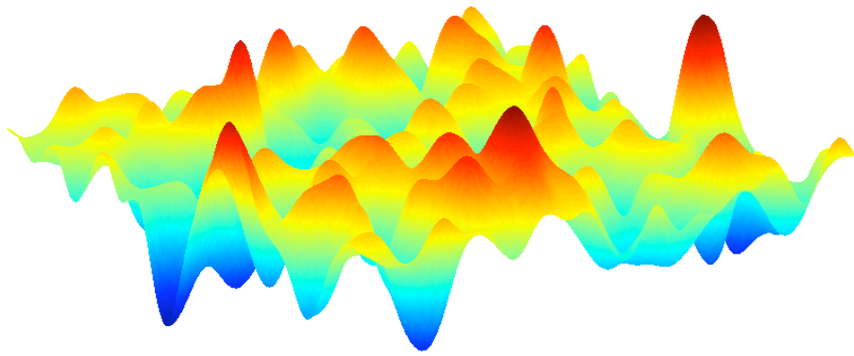
The analytic halo model of galaxy clustering

An *n*-point separation of scales



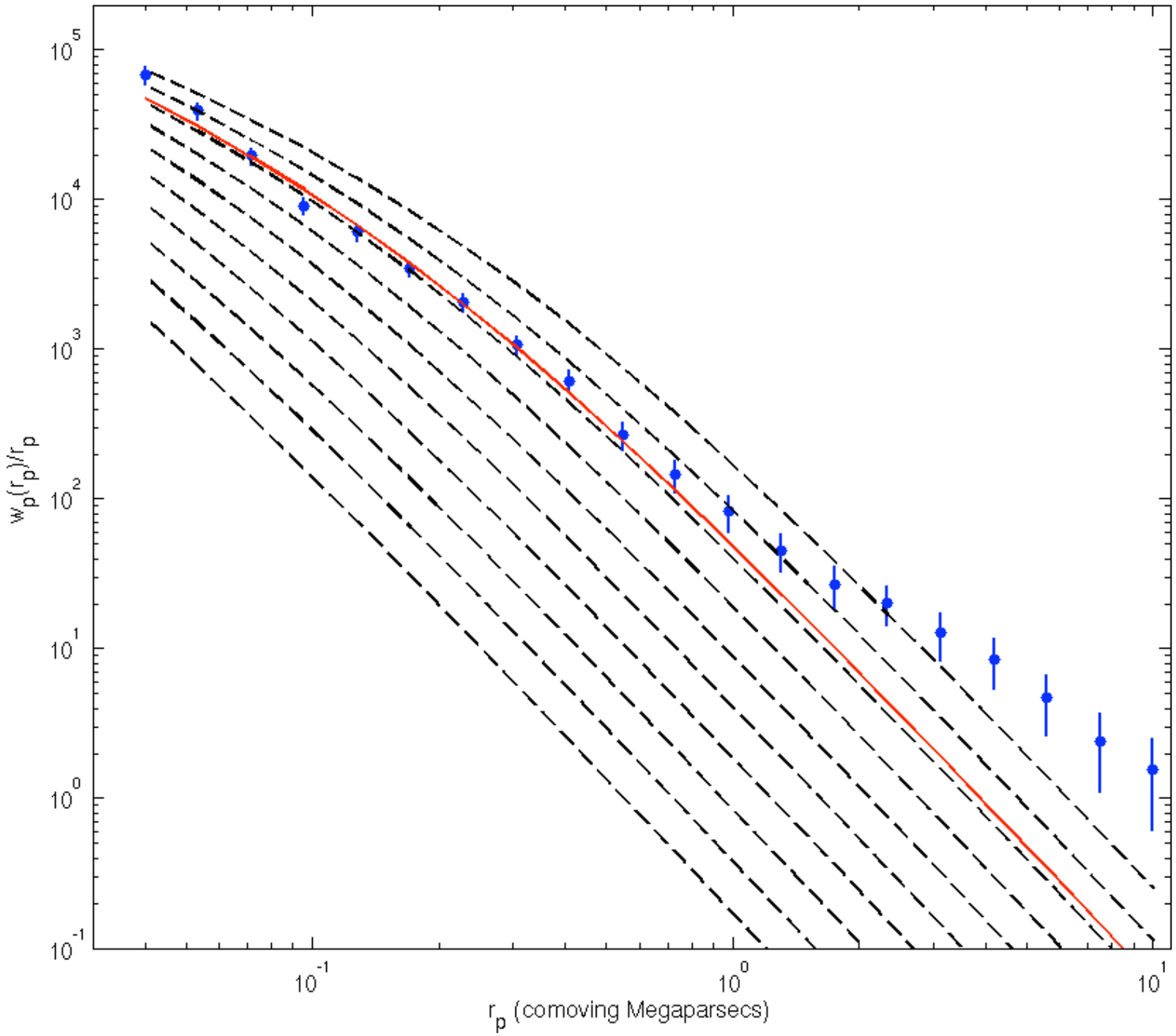
Clustering between haloes

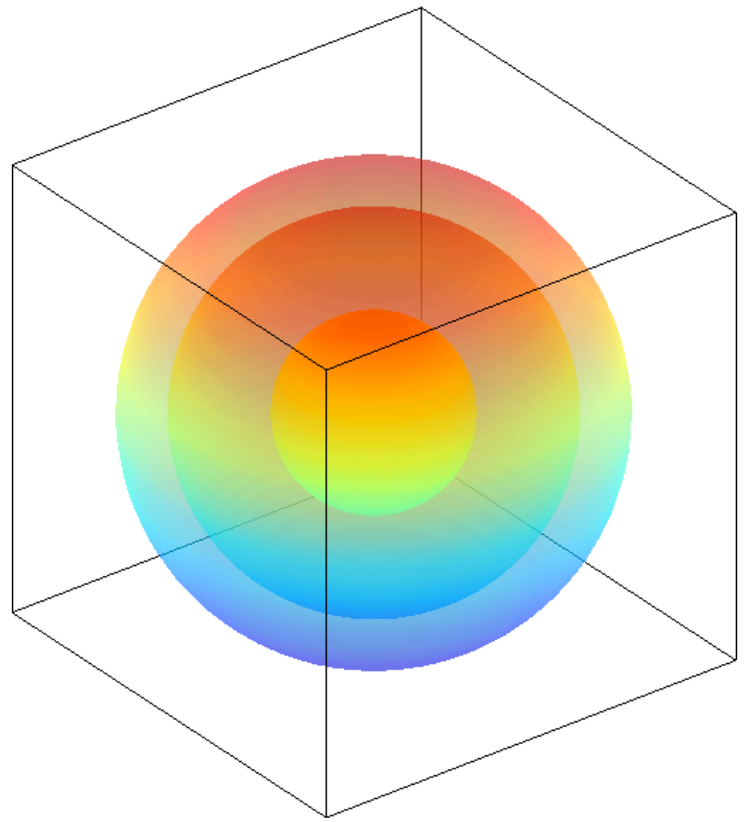




$$\nu \equiv \frac{\delta_c}{\sigma(M,z)}$$

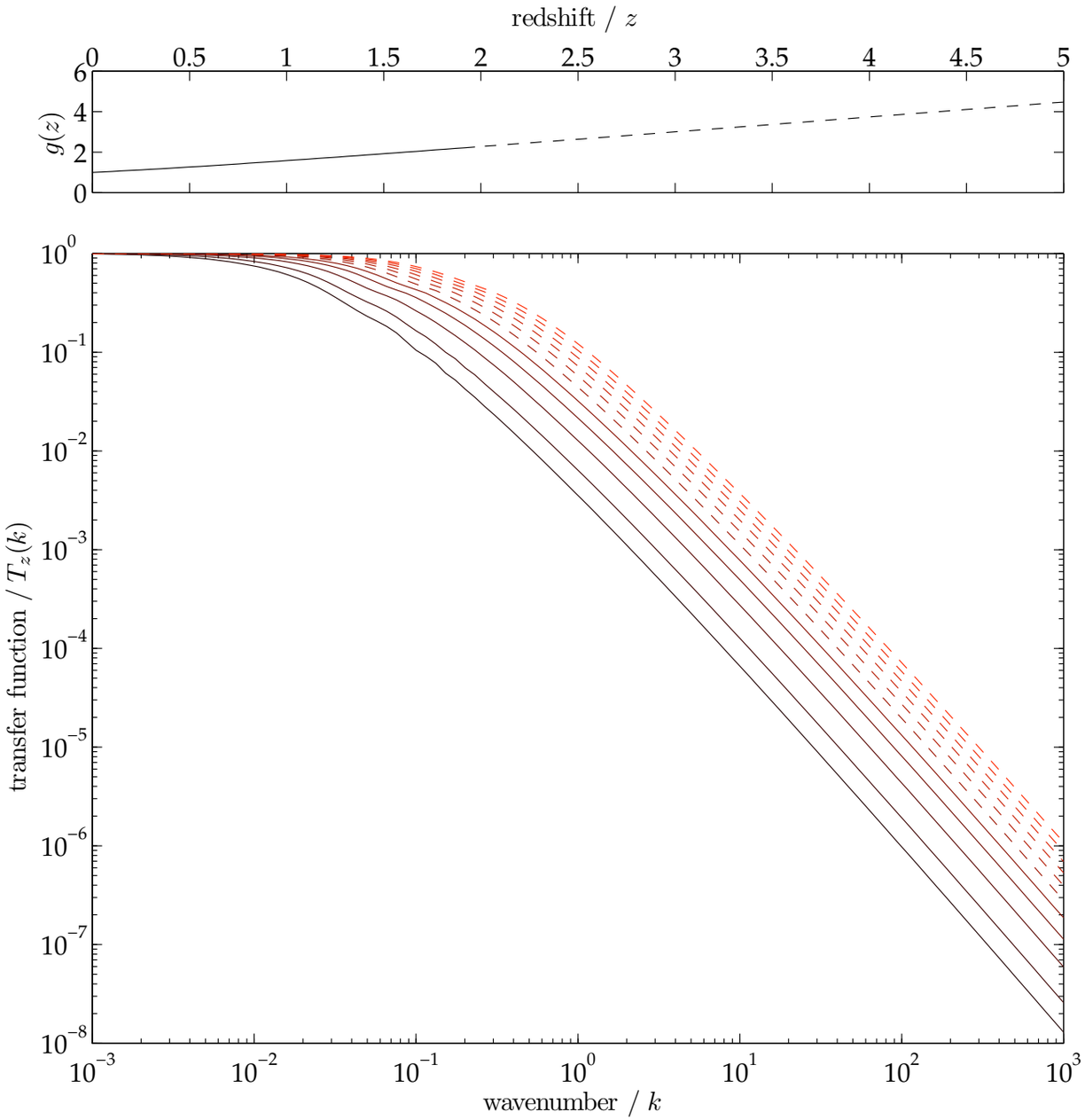
Clustering within haloes

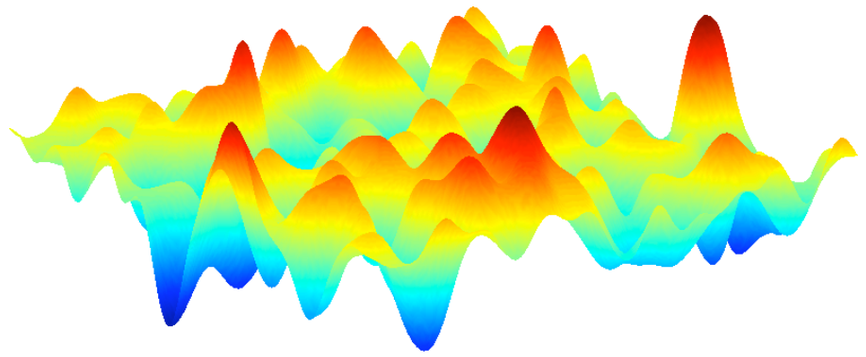




$$\frac{\rho}{\bar{\rho}} = \frac{\Delta_c}{\left(\frac{r}{r_s}\right)\left(1+\frac{r}{r_s}\right)^2}$$

Linear matter power spectrum



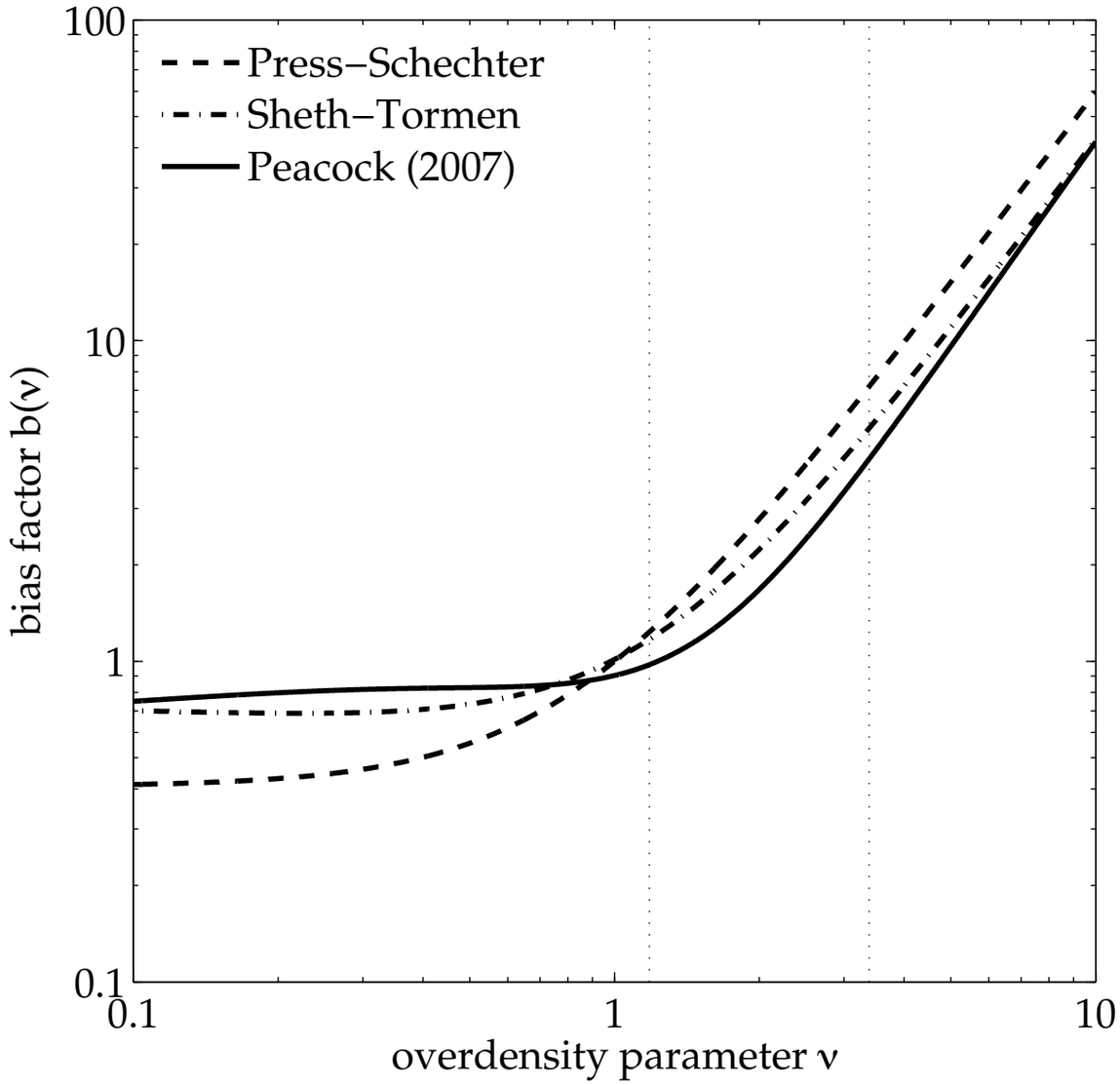


$$\Delta^2(k) = \frac{4}{25}\Delta^2_{\mathcal{R}}(k_0)\left(\frac{k}{k_0}\right)^{n_s-1} \times \left(\frac{ck}{H_0}\right)^4 T^2(k)\left(\frac{D_1(z)}{D_1(0)}\right)^2$$

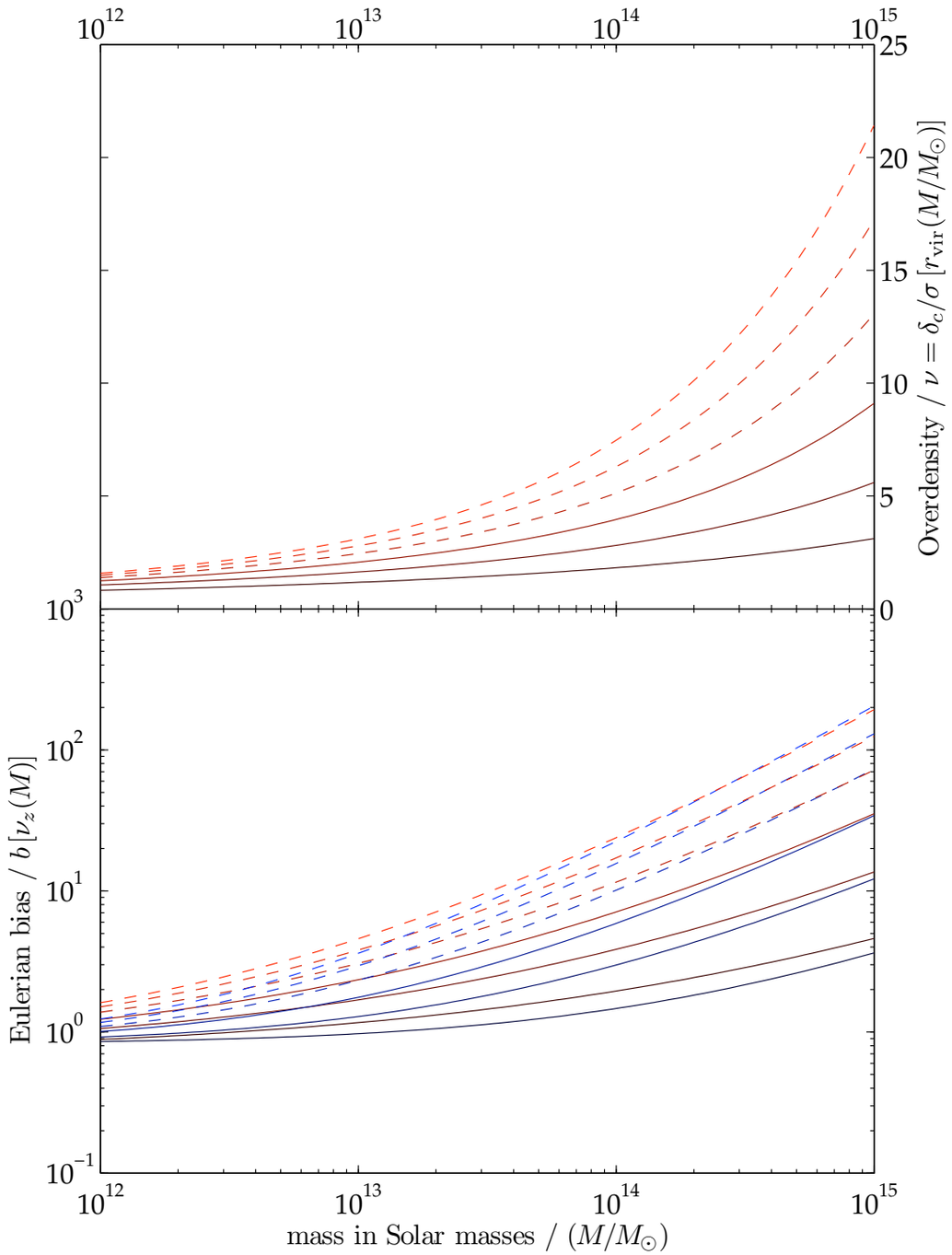
Bias: how clusters and galaxies follow dark matter

$$
\begin{aligned}
b_{\rm Eul} &= 1 - \frac{1}{\delta_c}\frac{d}{d\log\nu}\left(\log\frac{df_c}{d\log\nu}\right) \\
&= 1 - \frac{1}{\sigma}\frac{d}{d\nu}\left(\log\frac{df_c}{d\log\nu}\right)
\end{aligned}
$$

$$
\begin{aligned}
\frac{df_c}{d\log\nu} &= \frac{2}{\sqrt{2\pi}}\nu\exp\left(-\frac{\nu^2}{2}\right) \\
\Rightarrow b^{\rm PS}_{\rm Eul}(\nu) &= 1 + \frac{\nu^2 - 1}{\delta_c}
\end{aligned}
$$



Galaxy bias and halo occupation

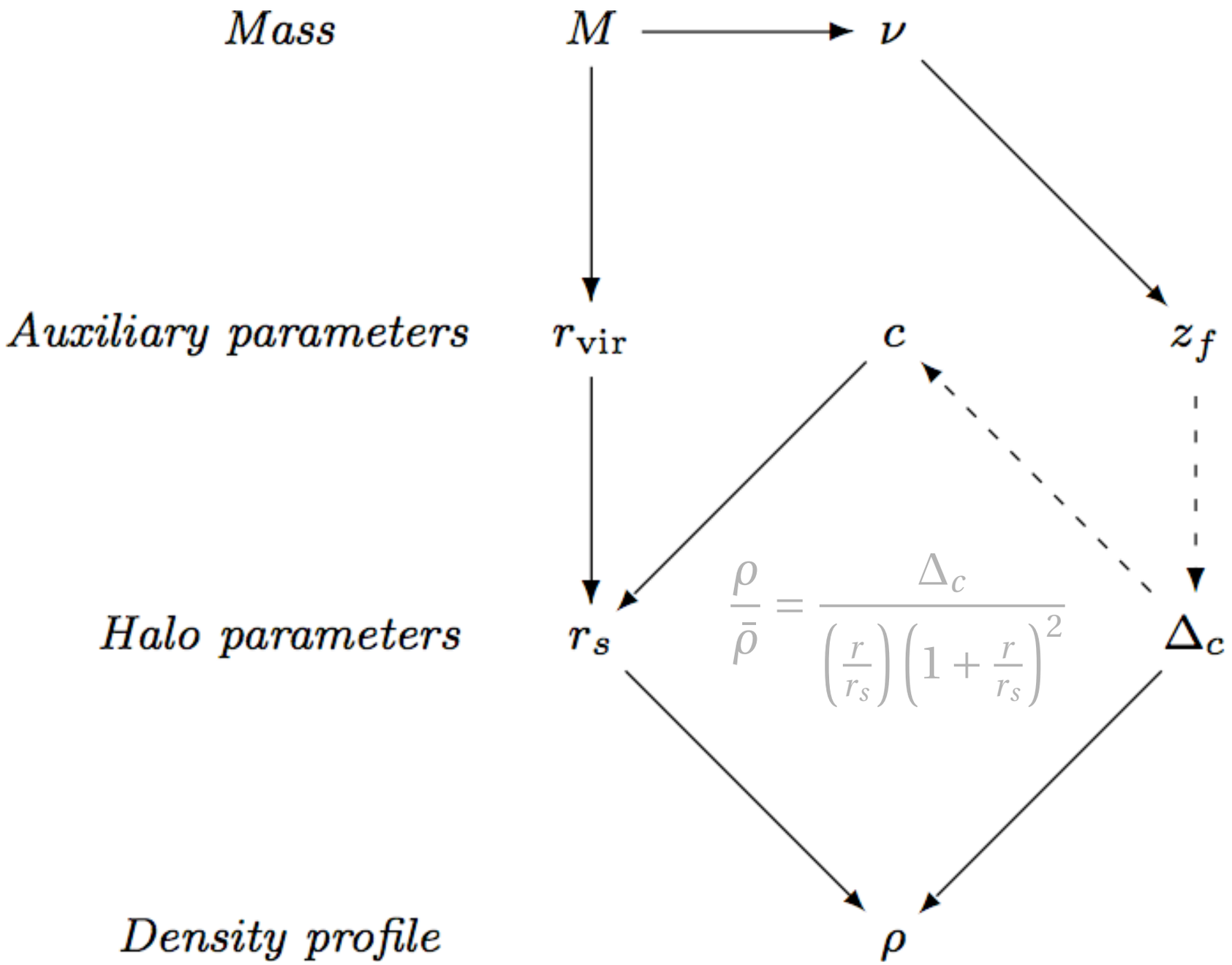


$$b_{\rm eff} \approx b_c(M) b_g$$

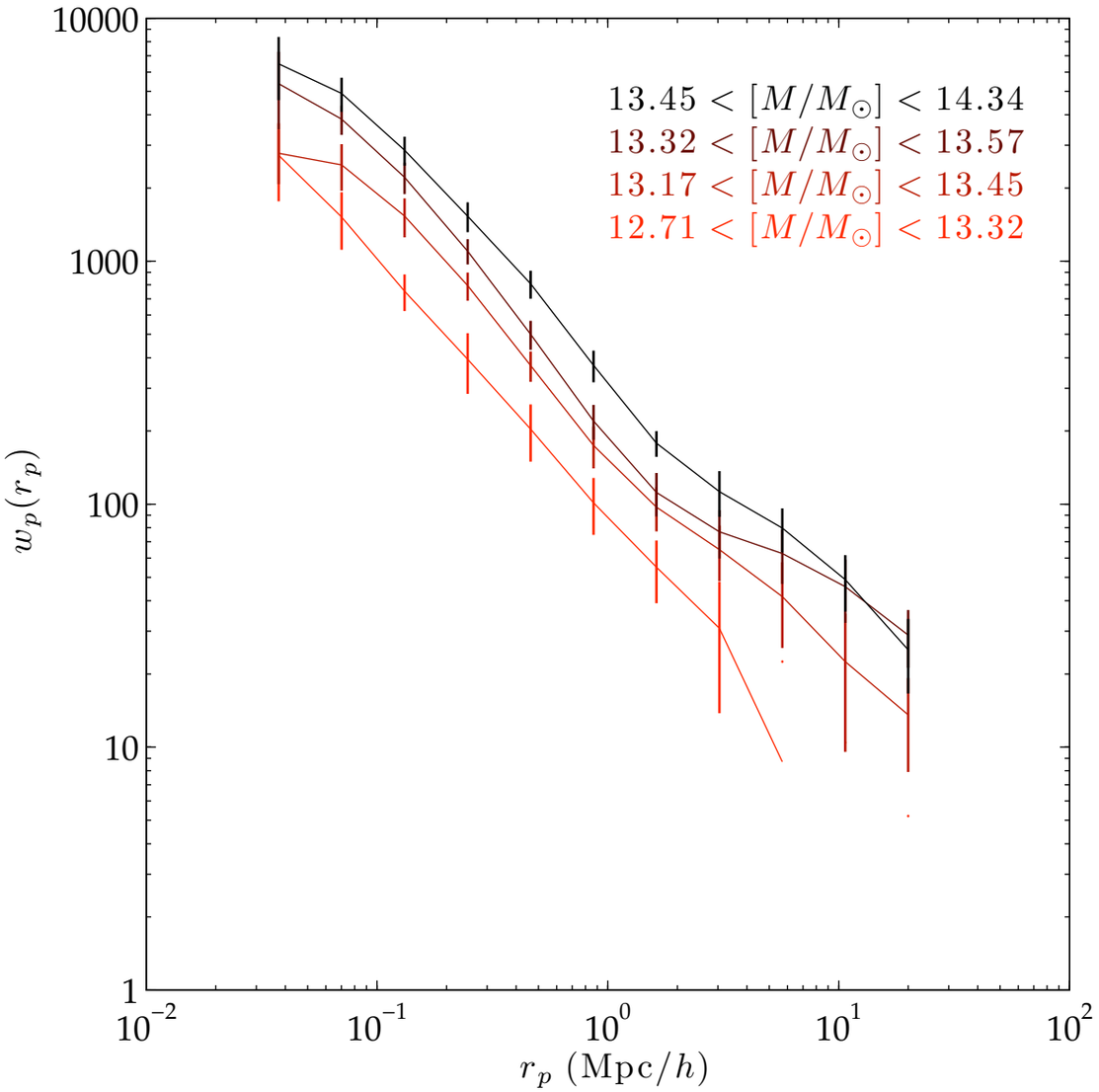
$$b_g = \frac{\int b_c(M)\langle N_g(M)\rangle n(M) dM}{\int \langle N_g(M)\rangle n(M) dM}$$

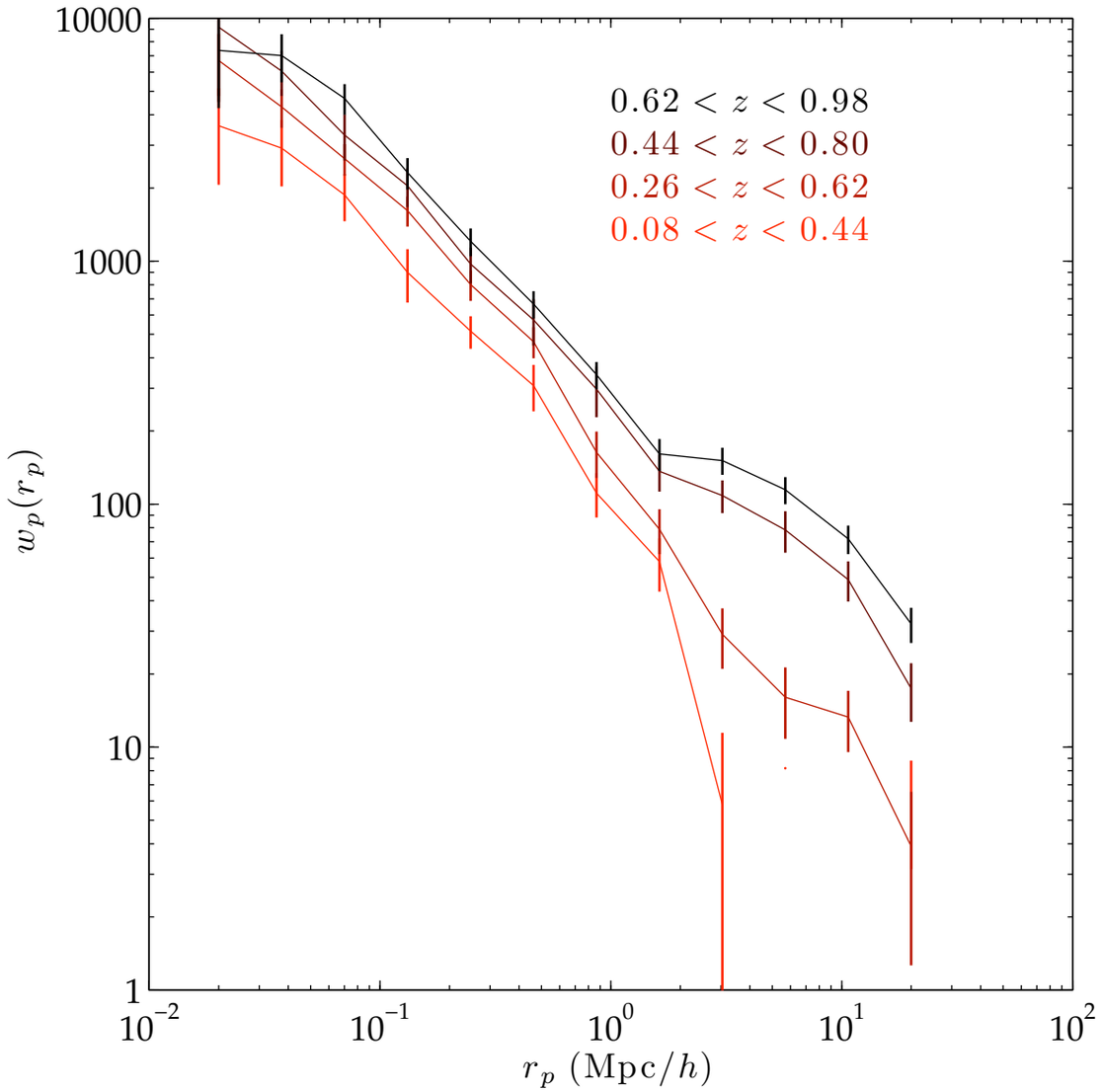
$$b_g \approx \frac{\sum_{i=1}^{n_c} b_c(M_i)\langle N_g(M_i)\rangle}{\sum_{i=1}^{n_c} \langle N_g(M_i)\rangle}$$

Density profile of dark matter haloes

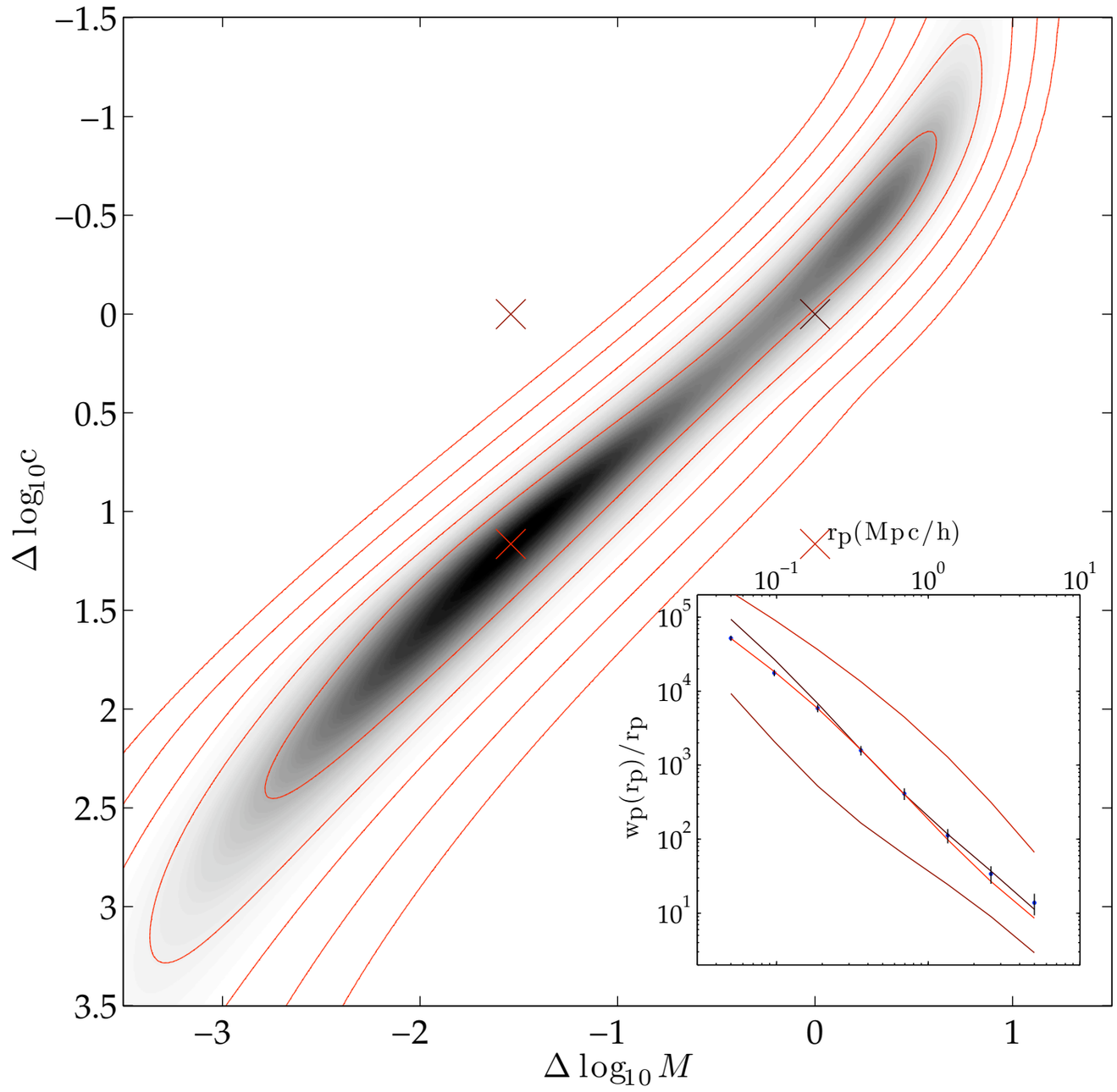


Cluster property dependence (preliminary)





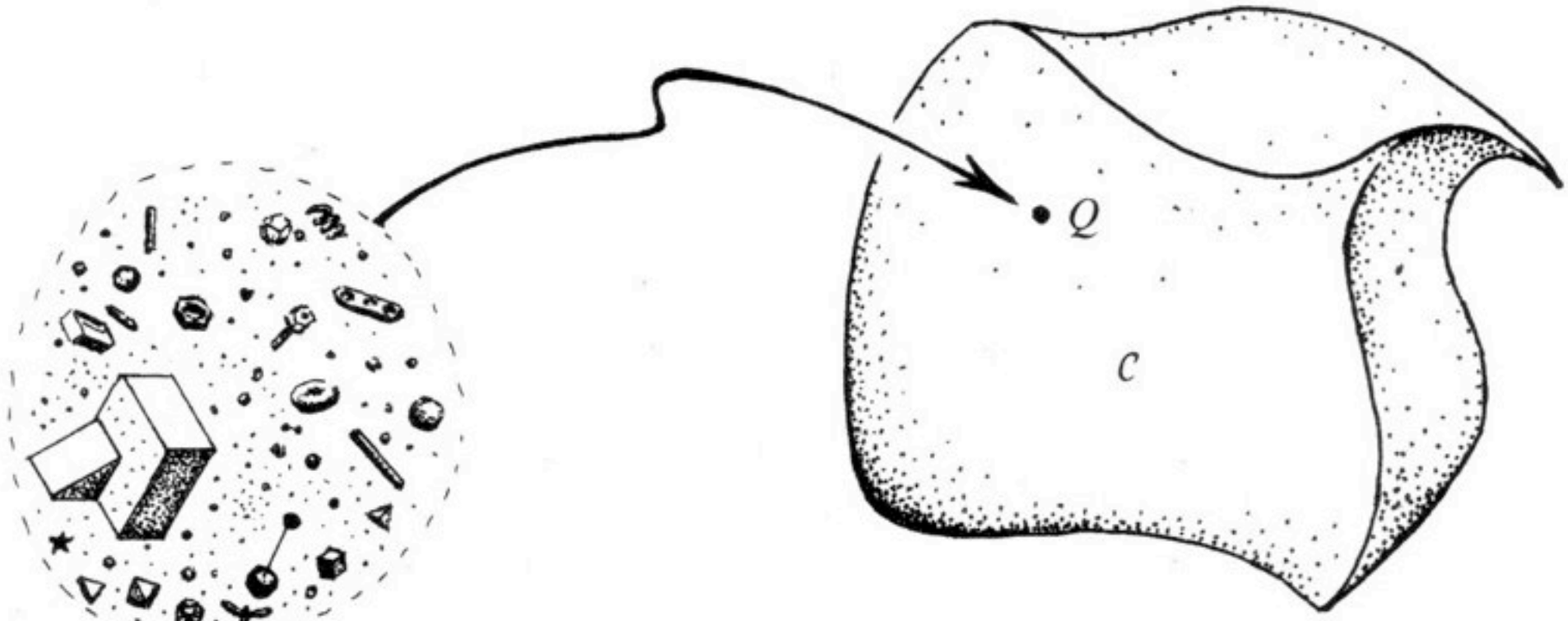
Mass-concentration relation



Three

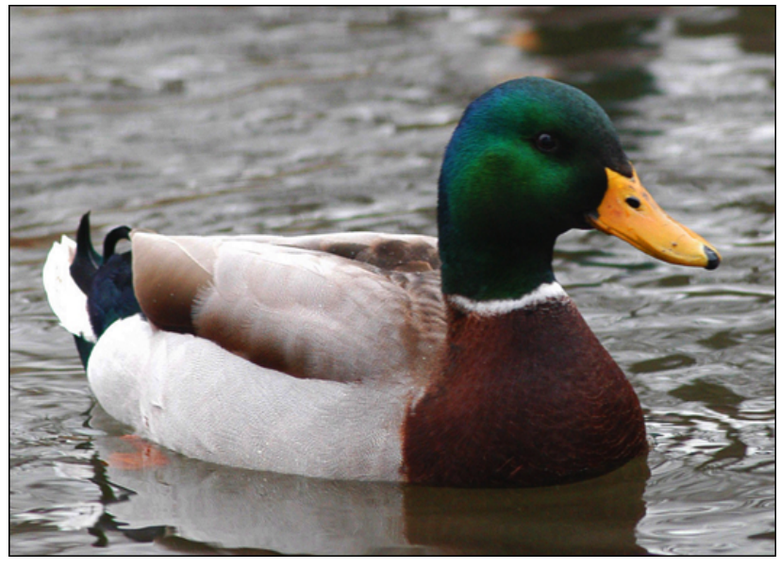
What are statistics of large-scale structure actually for?

Problem: Classification of density fields



How to classify everything that is not *x*

How to classify everything that is not *x*



List of non-Gaussian physical processes

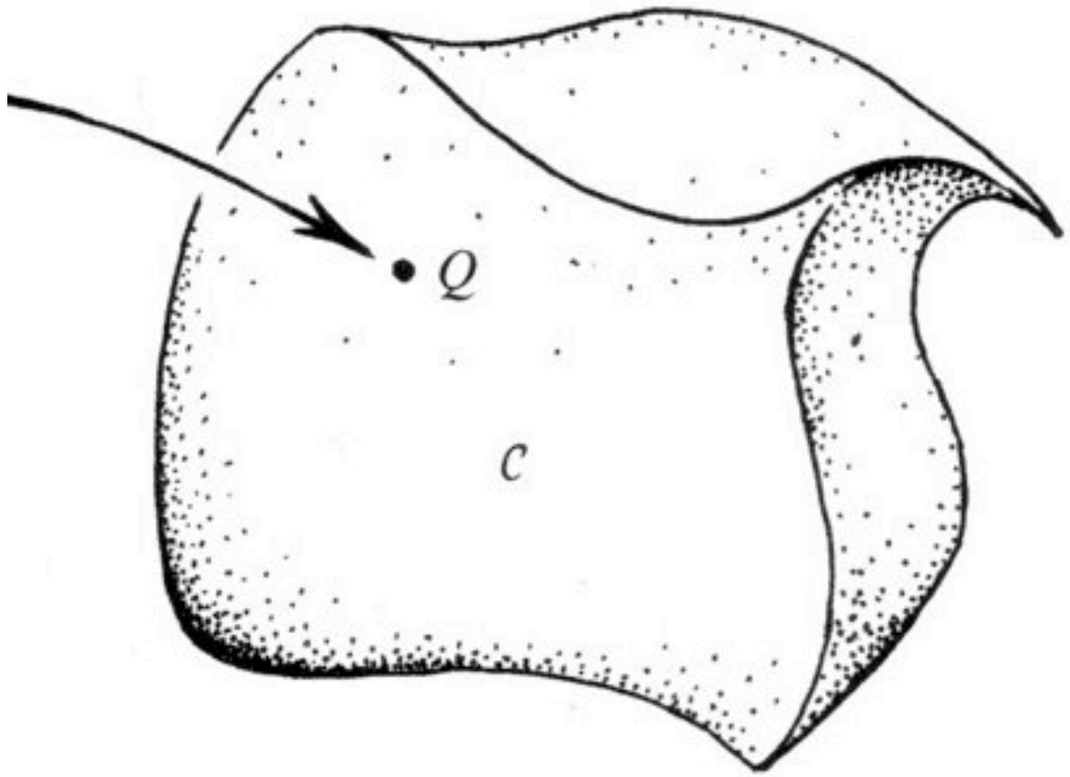
Non-linear gravitational evolution

Primordial non-Gaussianity

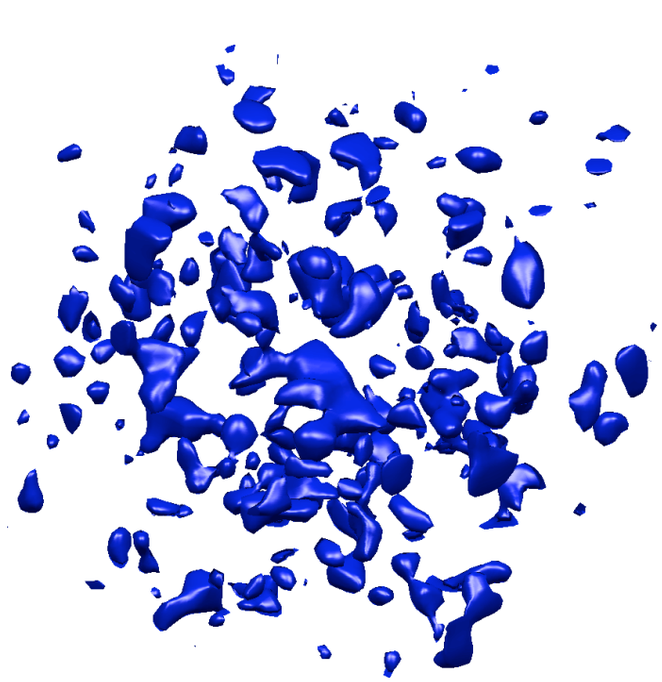
Redshift space distortion

‘Bias’

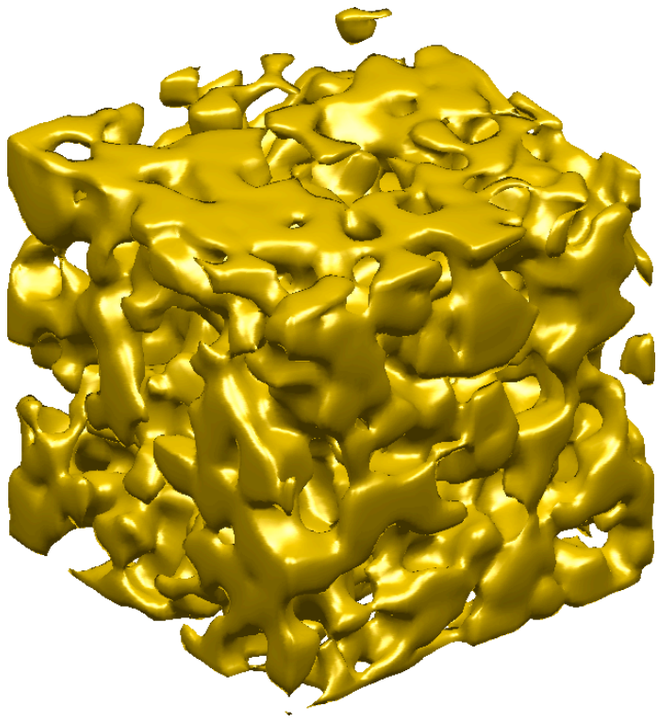
...



Contour surfaces through the density field



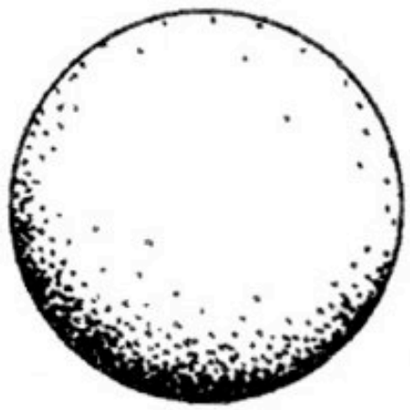
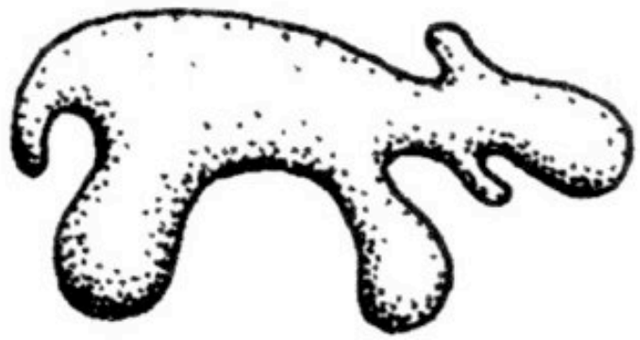
Voids

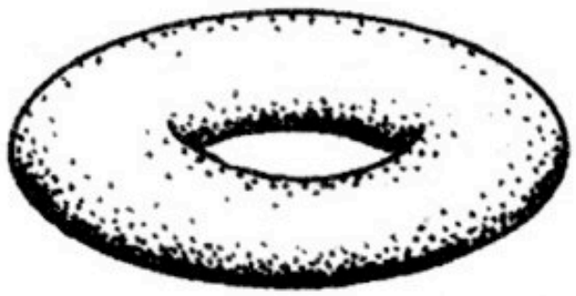


Filaments

Clusters

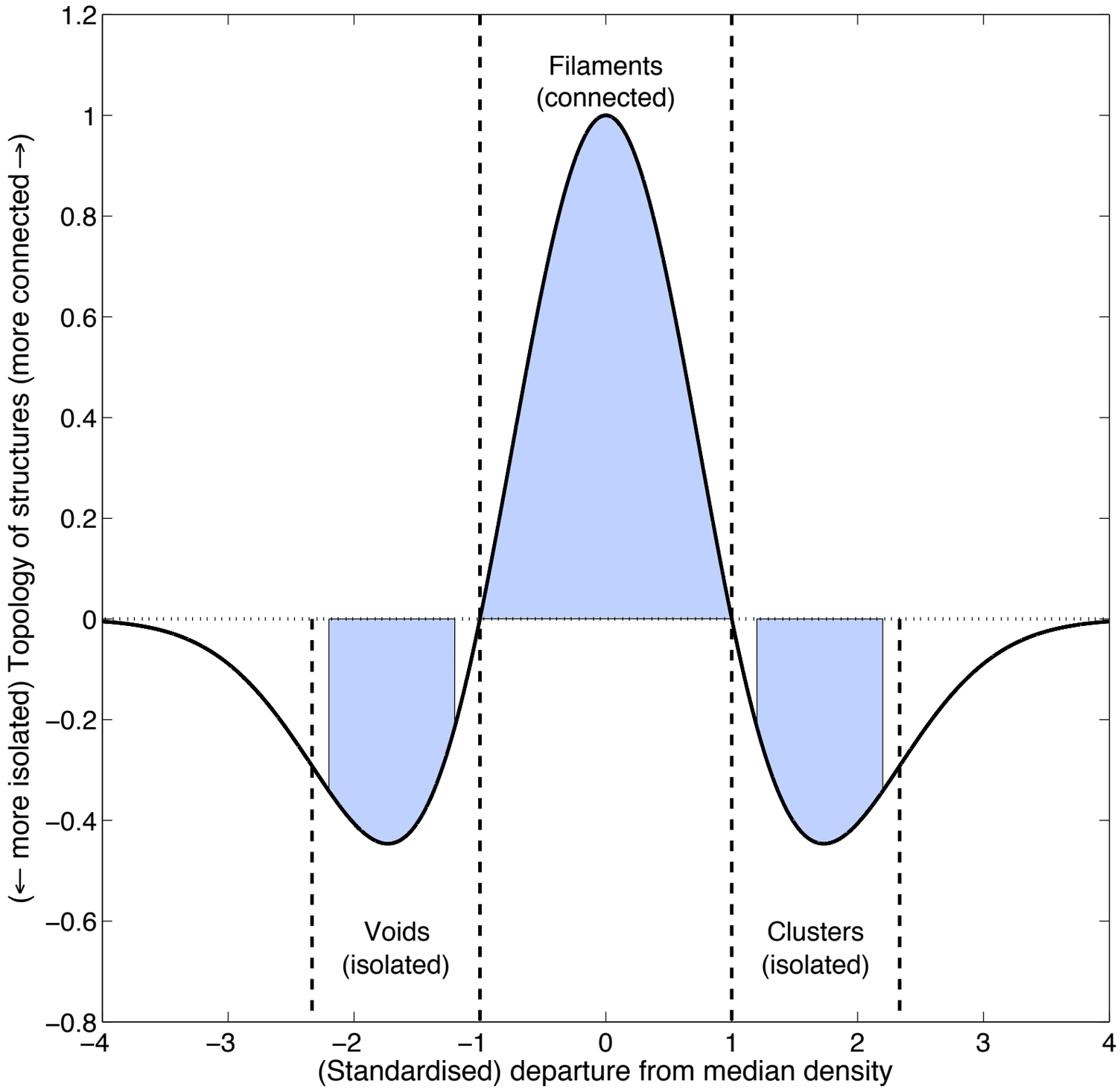
Genus number of contour surfaces

$g = 0$:  , 

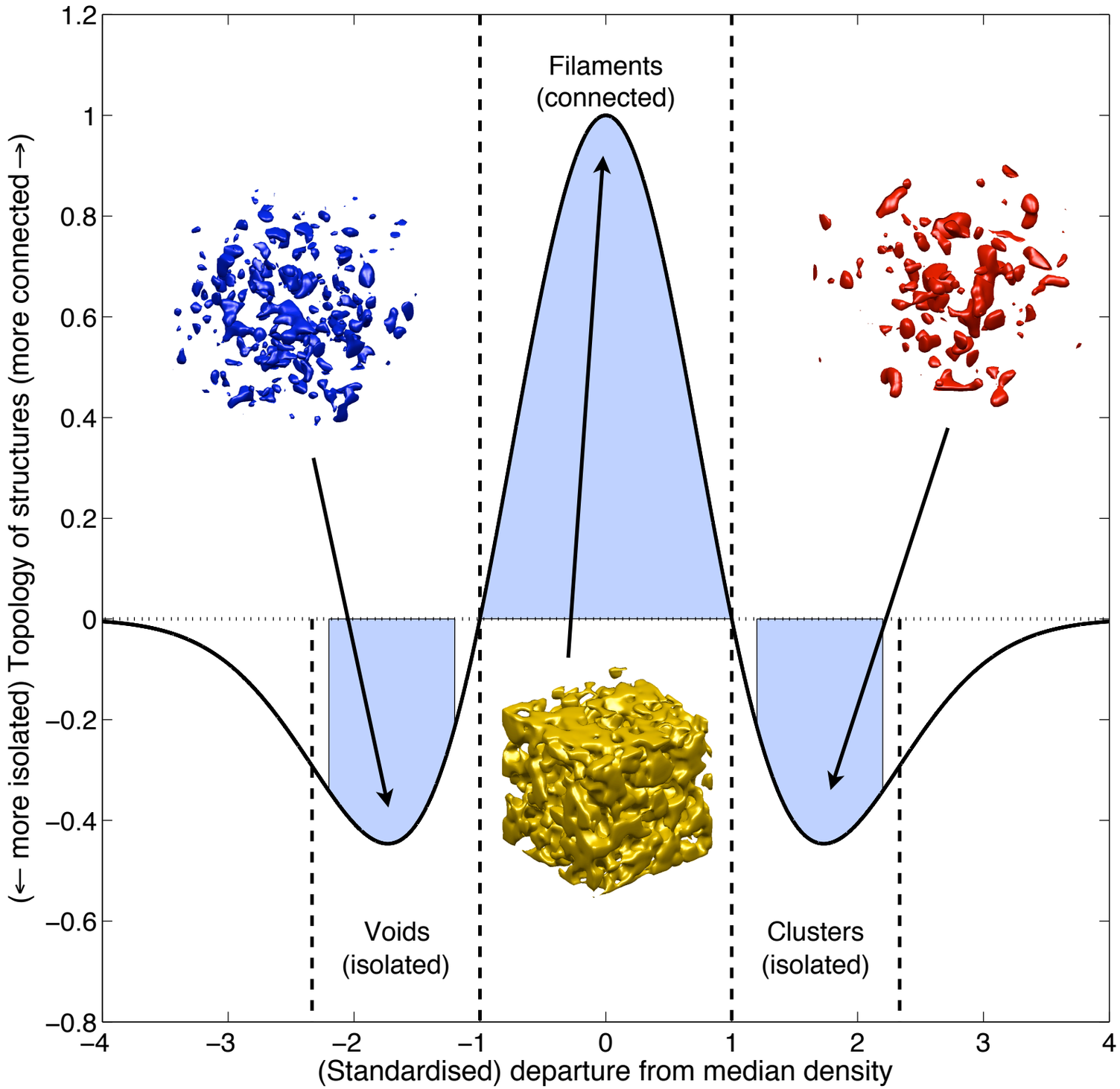
$g = 1$:  , 

$g = 2$:  ; $g = 3$: 

Genus curve of the density field

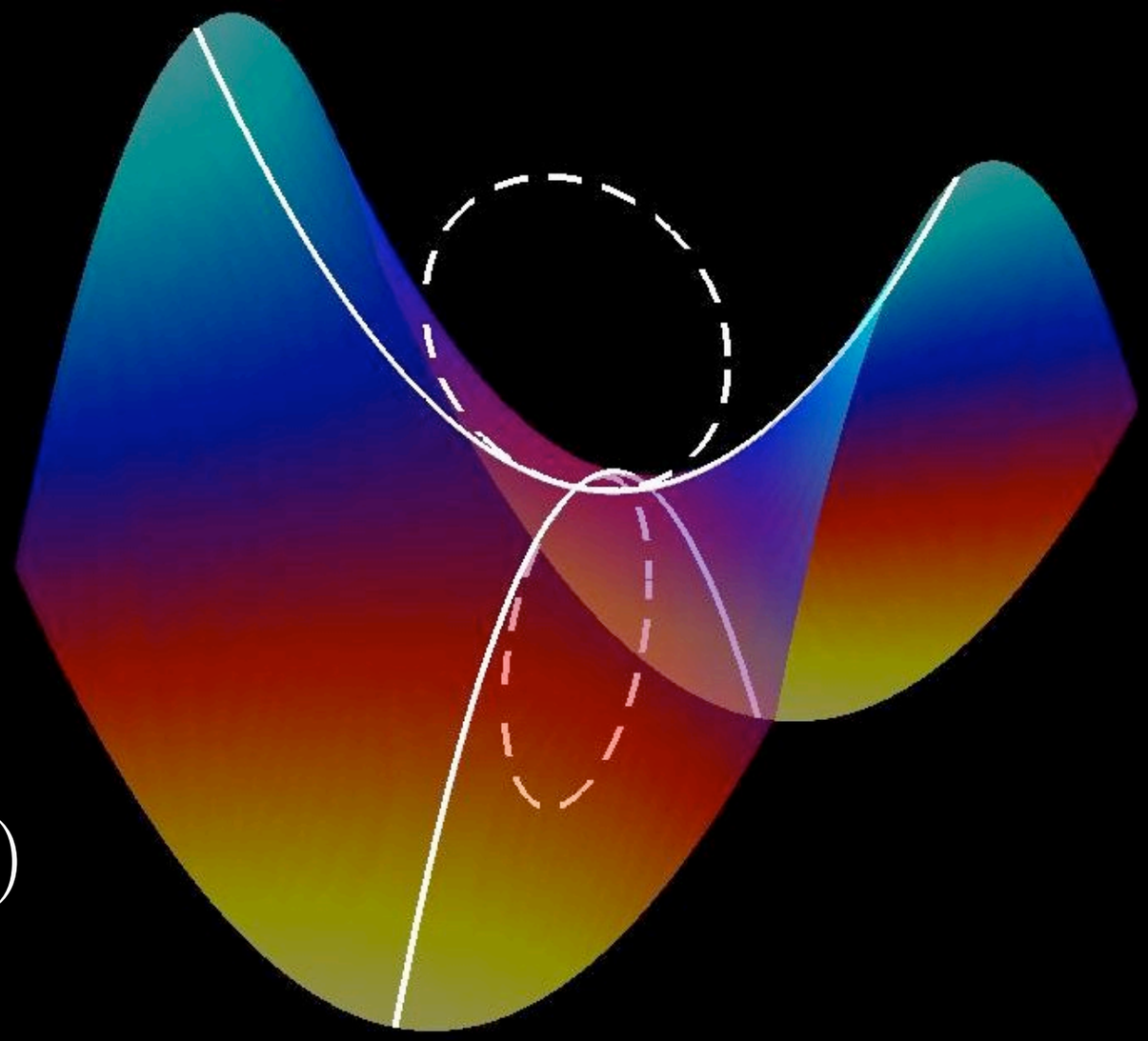


Genus curve of the density field



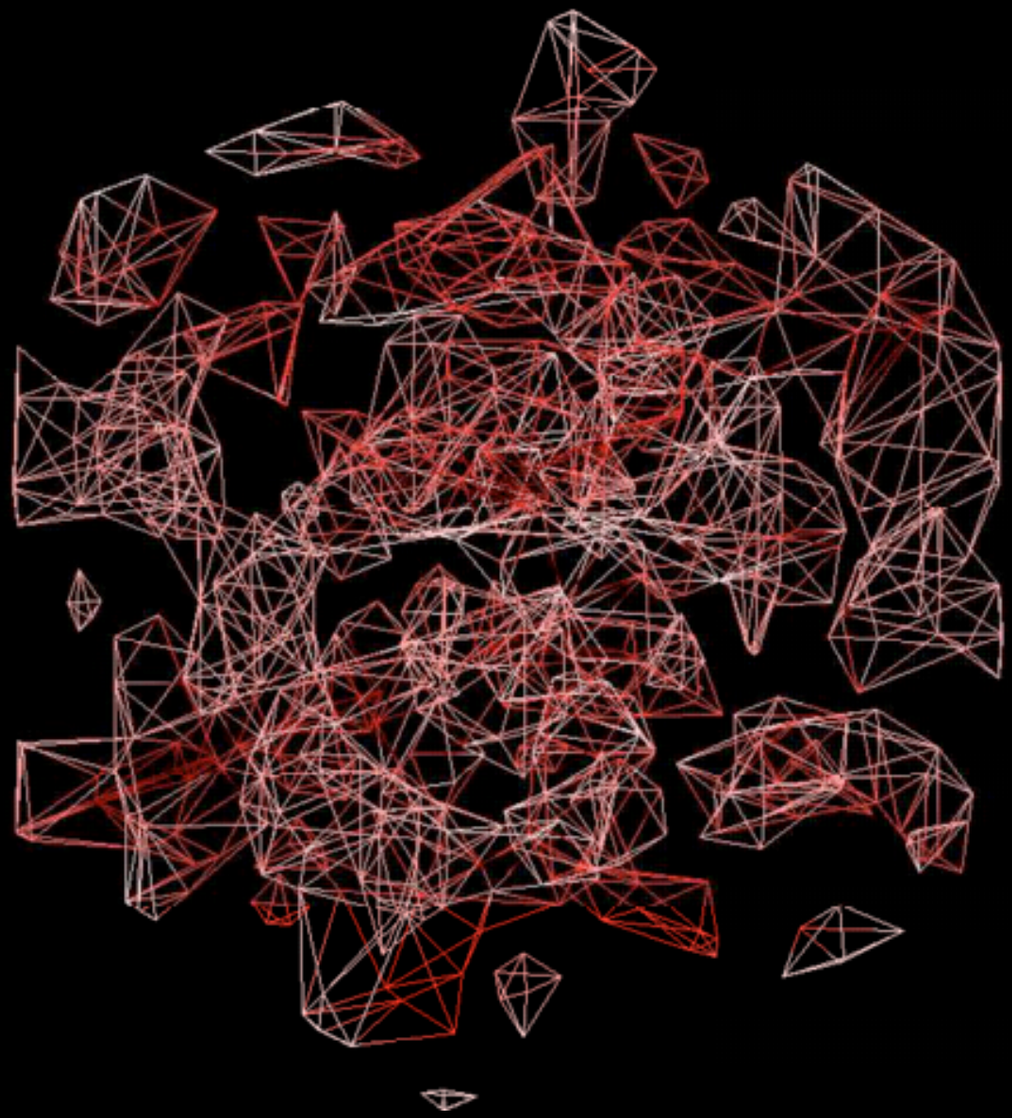
Digression: a differential topology calculation

$$K(x) = \frac{1}{r_1(x) r_2(x)}$$

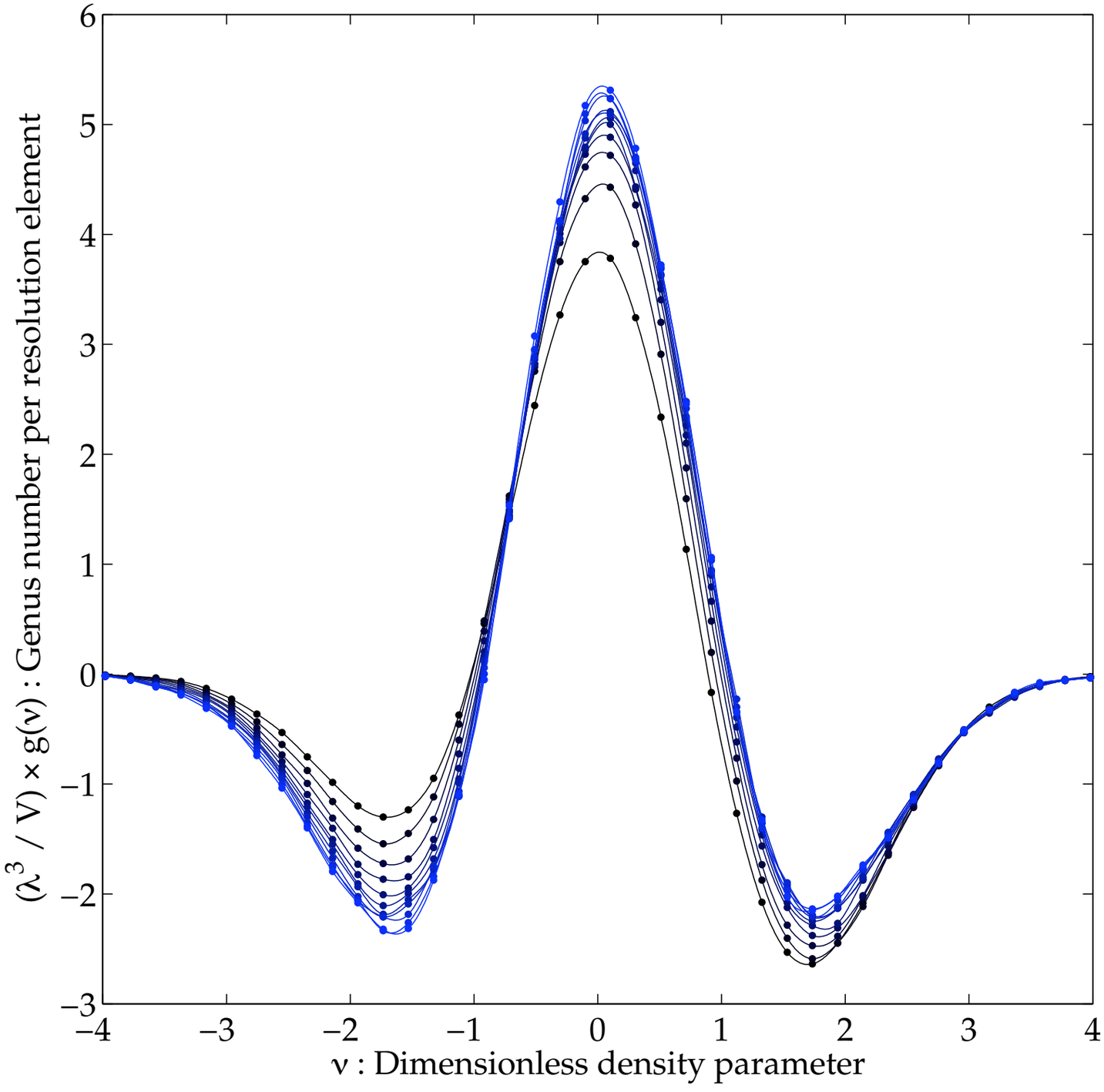


$$\int_S K dA = 2\pi\chi = 4\pi(1-g)$$

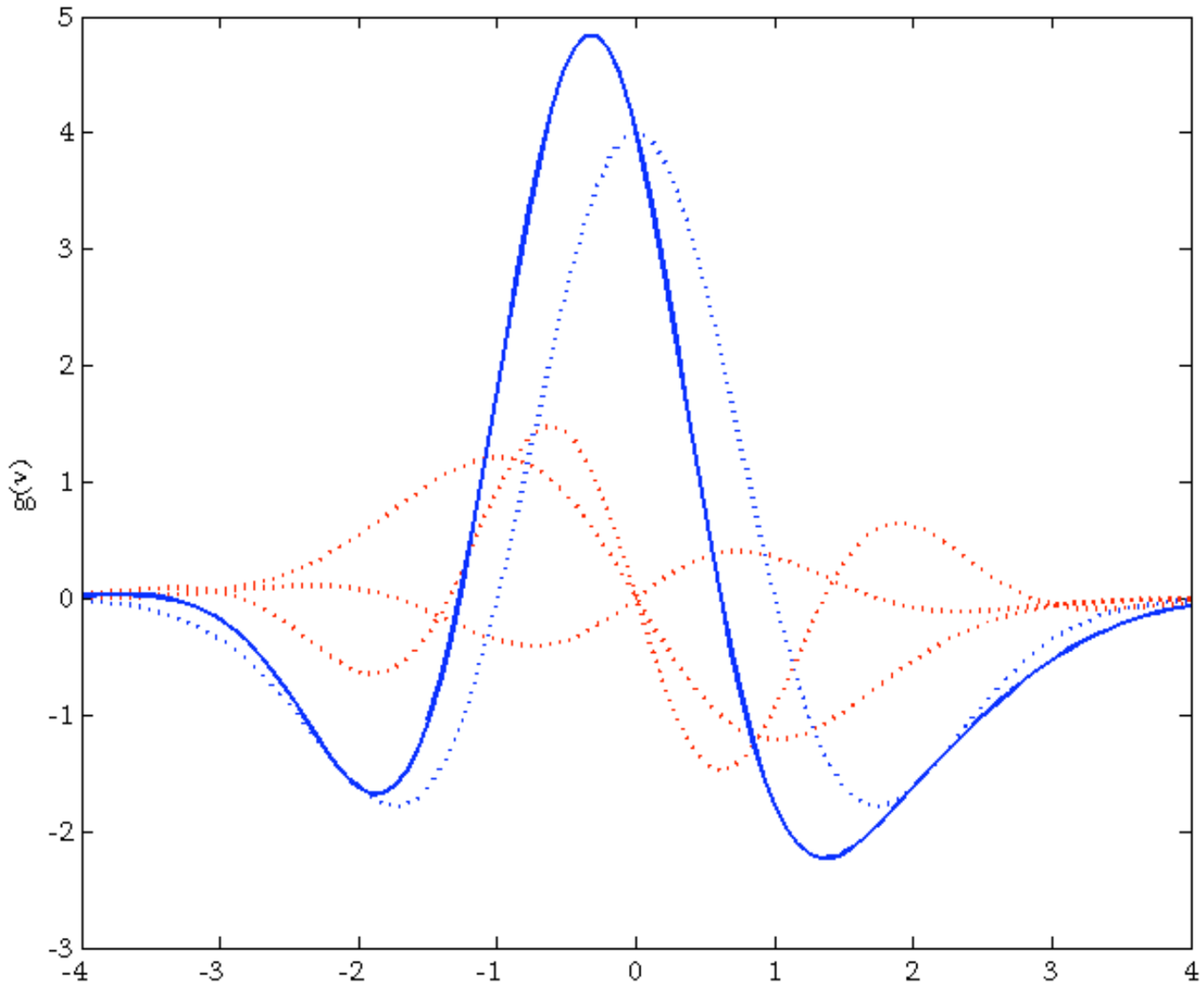
Digression: a differential topology calculation



Evolution of the genus curve

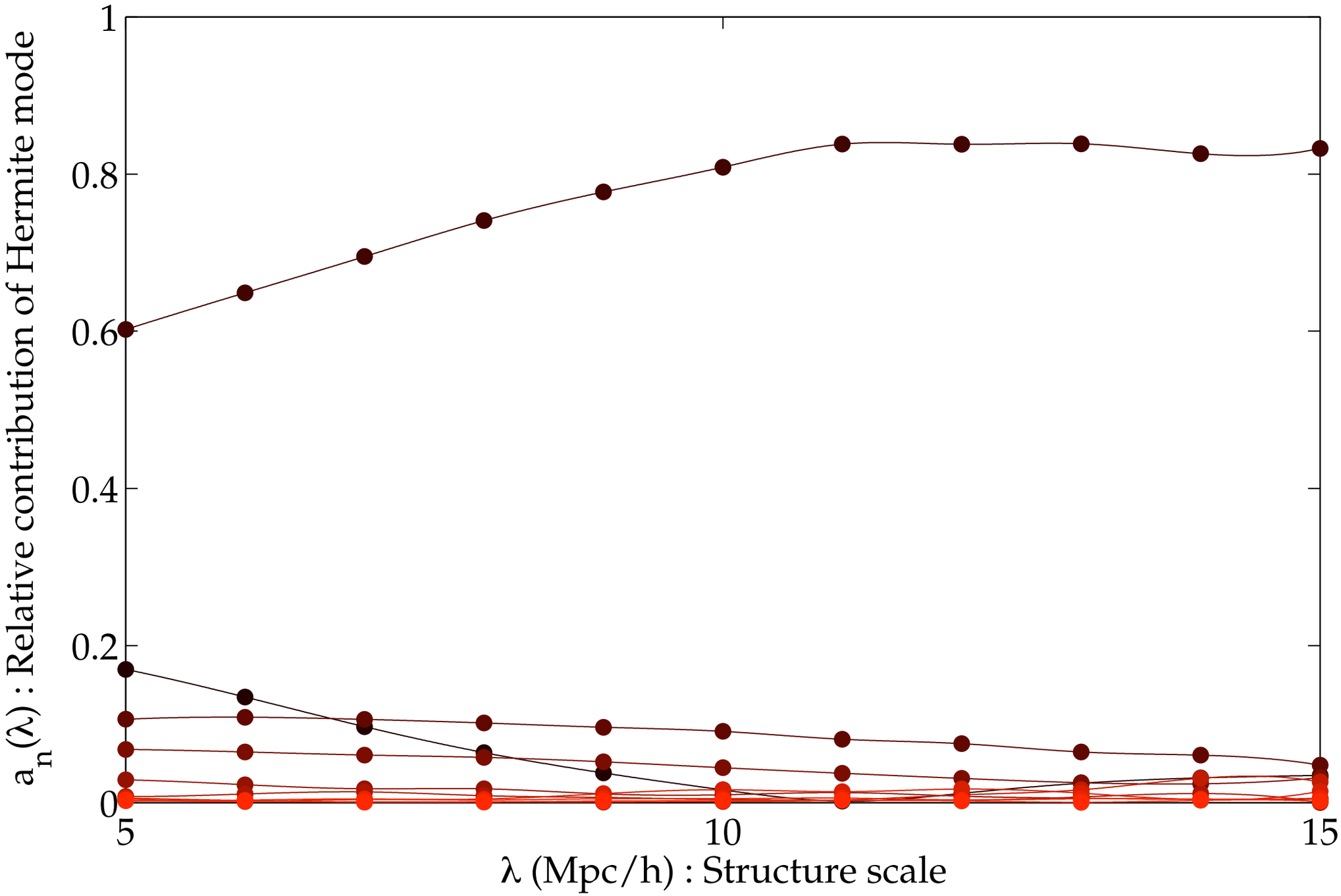


Evolution of the genus curve



$$g(\nu;\lambda) = \sum_{i=1}^{\infty} a_n(\lambda)\psi_n(\nu)$$

Evolution of the genus curve



Fin.